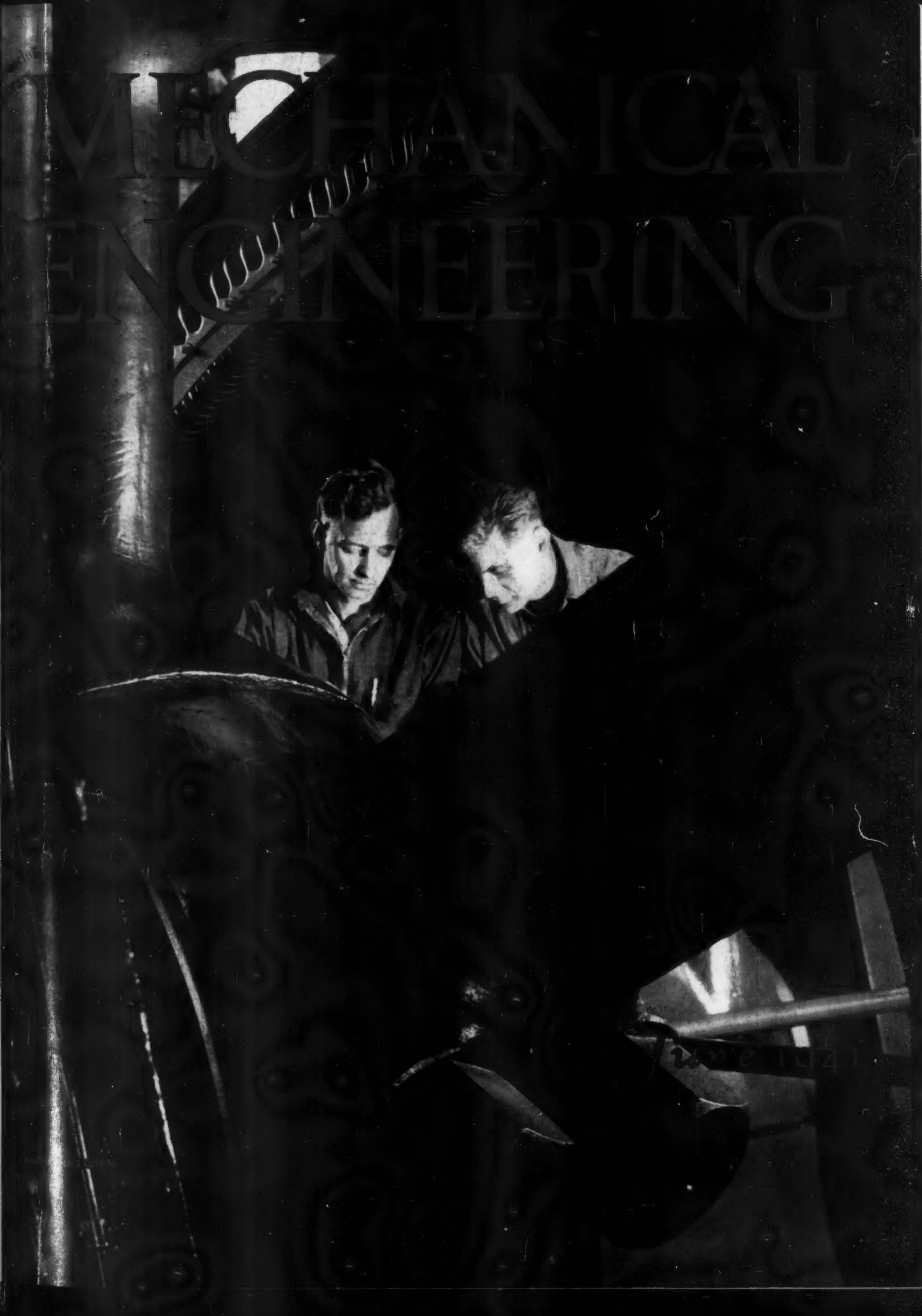
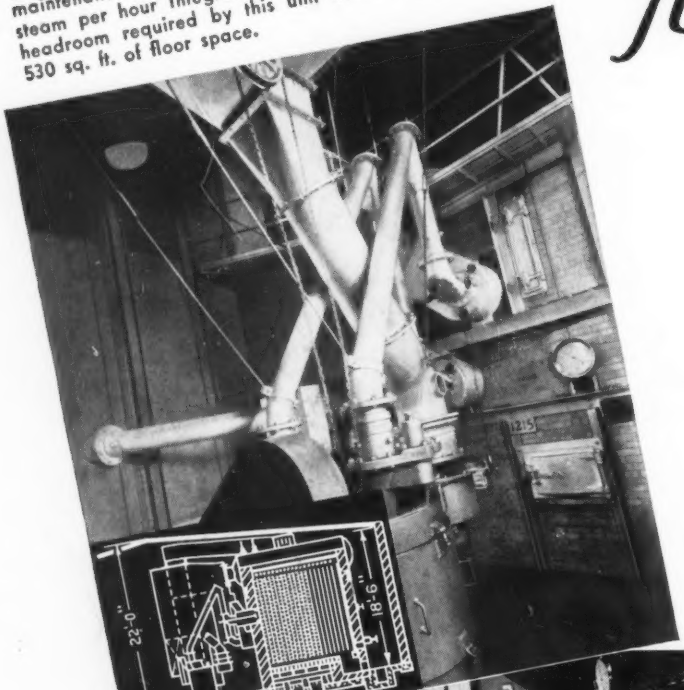
MECHANICAL ENGINEERING



June 1941

medium-size boilers
for limited space and lower fuel costs and maintenance

$5000 of the yearly fuel bill and $1000 of the annual maintenance costs were eliminated by this 30,000 lb. steam per hour Integral-Furnace Boiler. Note the low headroom required by this unit which occupies only 530 sq. ft. of floor space.



B&W Type H Stirling, Integral-Furnace, and Design 32 Cross-Drum Sinuous-Header Boilers are installed in small and medium-size boiler rooms throughout the country — fitted comfortably into cramped quarters — replacing inefficient fire-tube boilers without costly changes to ducts and breeching—making steam for less money—giving their owners the dependable performance that is a most valuable, though intangible, characteristic of all Babcock & Wilcox equipment.

Bulletins G-8-C, G-17-A and G-28 giving details of these boilers sent upon request.

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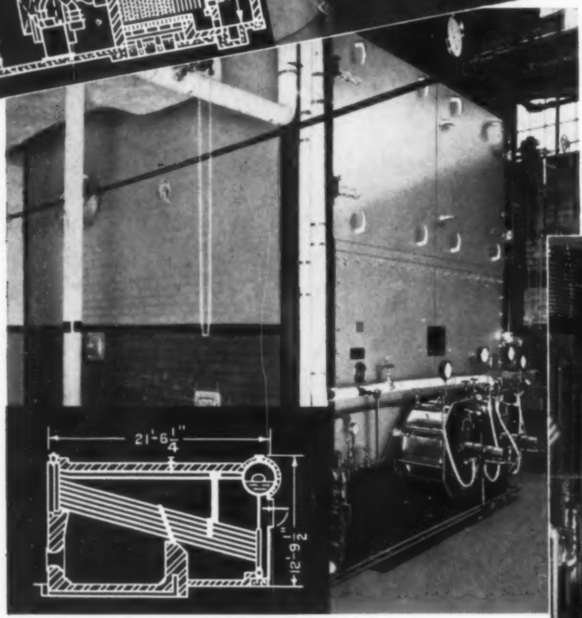
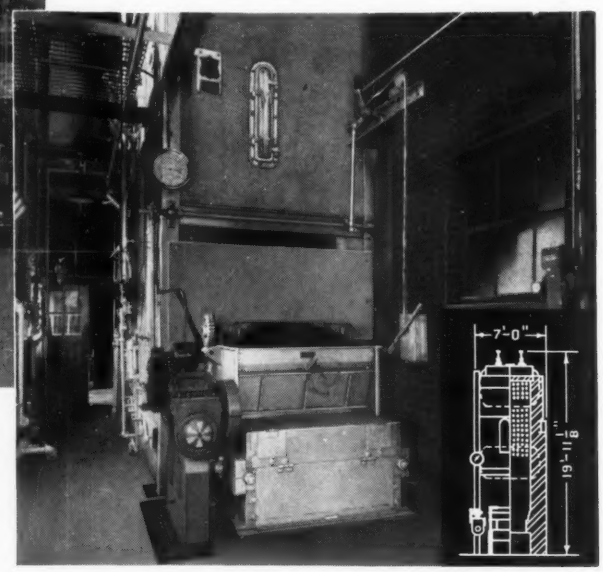


This B&W Design 32 Cross-Drum Boiler supplies 10,000 lb. steam per hr. maximum continuous capacity. Twenty-two feet long, 13 feet high, and 10 feet wide, this unit contains the straight-tube, header-type boiler's advantages in a moderately priced unit occupying little space.

Fitted into cramped quarters, width 7 ft., height 18 ft. 7 in., and overall length 17 ft. 8 in., this B&W Type H Stirling Boiler with B&W Chain-Grate Stoker delivers 7360 lb. steam per hr.



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Galloway, N. Y.

Men and Machines Against Time

(Workman at turret lathe in machine shop.)

Volume 63
No. 6

MECHANICAL ENGINEERING

June
1941

GEORGE A. STETSON, *Editor*

Sixty-Year Index

ALTHOUGH each volume of the A.S.M.E. Transactions has its own index, no single index of all of the volumes has appeared since 1923. At that time the Society published an index covering the first 45 volumes, but since then searchers have been forced to consult the individual indexes in order to locate references. With the close of sixty years of Transactions volumes, however, the project was undertaken to prepare a complete index of all of them, and this publication is now ready for distribution.

The new index differs from its predecessors in several particulars. Principally, its scope has been enlarged so that all technical papers that have been printed in any of the Society's regular publications have been included. The new index thus becomes a finding list of A.S.M.E. technical papers, rather than the customary index of the Transactions alone. The Proceedings, the *Journal*, which is now known as Mechanical Engineering, and the *Journal of Applied Mechanics* are covered by the new index. The reason for this is apparent when it is remembered that, although for a number of years the Transactions reprinted, with discussion, papers that appeared in preliminary form in Proceedings or the *Journal*, of late years this duplication of publication has been abandoned in the interests of economy so that even contributions of so-called "permanent value" are quite as likely to be found in Mechanical Engineering as in the Transactions.

Secondly, in the interests of providing a not too cumbersome list, the decision was reached to confine the new index to technical papers, omitting a considerable amount of material relating principally to Society and Committee affairs, and the memorial notices to deceased members.

A third difference will be found in the absence of references to discussers, an omission decided upon in order to reduce the number of references in the author index.

The fourth difference is in the arrangement. Instead of a single alphabetical list, there are two—a subject index, carefully cross-indexed, and an author index in which references are given to the subject index, by year of publication.

Lastly comes another innovation in arrangement. In both lists, under any subject or author's name, the references are arranged chronologically. This feature is most useful as it applies to the subject index and reveals many interesting facts. For example, it can be noted when a subject first engaged the interests of the Society, how long interest in it flourished, and when, if ever, it died out. Thus it will be noticed that from almost the first to the sixtieth volume the Society's publications have contained articles on lubrication, but that beginning about 1915 the number increased greatly. It was in 1915 that the Society organized its special research Committee on Lubrication, and hence the effect of this Committee's activity on the literature of lubrication is significantly indicated. When the steam engine began to decline and the steam turbine to grow in interest may be noted, as well as the shift from stoker firing to pulverized-coal firing and other ups and downs of technological developments. Not the least interesting is the list of subjects of presidential addresses, and the names and concerns of engineers of former generations.

Here then, within the compass of 190 pages, will be found the key to a rich and important literature. The treasures it will unlock and the time that will be saved, engineers who have occasion to consult A.S.M.E. publications will readily appreciate. A.S.M.E. Transactions and Mechanical Engineering are on the shelves of all important libraries. With the Sixty-Year Index at hand, engineers whose personal libraries are incomplete will be quickly led to the resources of the extensive literature accumulated in the Society's publications.

Production and Management

SLIGHTLY more than a year ago, following the collapse of the British-French campaign in Western Europe, the epic evacuation of Dunkerque, air raids on British cities, and serious attacks on British commerce on the sea, there crystallized in Great Britain a unity of purpose and a will to victory that have heartened all lovers of "life, liberty, and the pursuit of happiness" the world over. Less spontaneously, because the danger has seemed more remote, the people of the United States have been roused to national defense and a policy of aid to England and other free but threatened nations. With appropriations already approximating twenty billions a terrific load has been thrown upon production capacity and man power in this country as a foretaste of demands yet to be made. History will clarify the nature and intensity of the social, economic, and political forces unleashed all over the world which brought about these events and will record the success with which our people and their institutions, particularly their genius and ability in production, are meeting the emergency. Never, it seems, have engineering talent and managerial skill been put to such a test.

Coincidentally with the violent remaking of the world

about us, internal problems which are most dramatically evident in our industrial relations, have developed to their critical phases. The times and the emergency have let loose disturbing forces within our peaceful and easy-going nation. Here again the test of engineering method and administrative skill is in the making.

Fundamentally, from an engineer's point of view, the immediate task of the United States is one of production engineering, a field in which this nation is pre-eminent. To avoid the false complacency of oversimplification and overconfidence, it is necessary to inquire what production engineering is and what it implies. For this task Professor Buckingham has provided a far-reaching outline in an article to be found in this issue. Even engineers will be impressed with the comprehensiveness of the subject, and the high quality of skill necessary to master and administer it. It is more than a technique by which manufactured goods are made available for human use. It is a way of life for millions of men and women. It is a major engineering activity. It is fundamental to our industrialized society. On the manner in which it is conducted hangs the fate of the nation and the world. The men who administer its varied techniques have no less responsibility than this. The responsibility calls, as Mr. Batt asserted when he received the Gantt medal last month, for statesmanship in management.

Who is going to train men to develop the necessary qualities of statesmanship in industrial management and what groups are going to uphold these men in the determination to exercise their statesmanship? The answers seem clear. First there are the schools and colleges in which must be acquired more than the fundamentals of technical education. The schools must extend their efforts to awaken in engineering students a realization of the need for this statesmanship in management. And when the school has finished its task, the engineering societies and the heads of industrial enterprises themselves must see to it that the environment of industrial management is a stimulating one for eager minds to thrive in. Men like Mr. Batt are striving to create and maintain this environment in the business world. Engineering societies are destined for small and unimportant roles if they do not continue to add their influence to this end in industry and the world at large. In a report to the E.C.P.D., printed in this issue, Robert E. Doherty sounds the professional keynote: "The engineering profession . . . . faces the imperative challenge of the unstable new world it has helped to create, and the opportunity to take a hand in stabilizing that world." This is a task for statesmanship of a high order.

Statesmanship and stabilizing the world are high-sounding phrases. They leave the young man and the ordinary fellow with an easy avenue of evasion. "We are not statesmen or managers or world stabilizers. We don't give orders; we follow them." True; but herein lies one of the greatest weaknesses of industrial relations today. Those who sit at the side of the table have to pass the plates both ways. They must not only pass down the full plates, but return the empties for the second helping.

In dozens of ways such men are the best intermediaries; for management has a two-way traffic whose communication lines are numerous officials from the general manager to the foreman. Unless flow is maintained in both directions, management fails just as tragically as though it had ceased to function at its source. Such dynamic stability engages everyone, and falls, in an industrialized civilization, most heavily on engineers. The threatened dangers of world changes from without are designed to make this stability depend on a one-way traffic. In our internal changes we shall show statesmanship and a dynamic stability by maintaining a two-way flow.

What's Your Definition?

TRY this sometime and note the result: Ask someone to define mechanical engineering. Or better yet, sit down and write your own definition.

A Committee on Industry of the National Conference of Engineering Positions, composed of W. F. Carhart, W. L. Cisler, H. B. Oatley, and R. L. Sackett, chairman, was given the task of writing a definition of mechanical engineering. Curiously enough, The American Society of Mechanical Engineers has never officially adopted a definition of mechanical engineering. Nor for that matter, in so far as the committee could discover, has any of the Founder Engineering Societies ever officially adopted a definition of its particular field of engineering. Anyone who has tried to write such a definition will readily understand the reasons, and anyone who has attempted to get a considerable number of persons to agree on a definition is conscious of the difficulties.

But the Civil Service Commission wanted a definition and put the matter up to the A.S.M.E. The committee circulated various proposed definitions for criticism and received many others. Because emphasis was laid by some engineers on one factor, and by others on another, and because the definitions ranged from generalities to detailed specifications of fields and duties, agreement on any particular wording seemed hopeless. Nothing daunted, the committee prepared a definition which it submitted to the A.S.M.E. Council who approved it, but did not adopt it, and ordered it printed for comment by members. It reads:

"Mechanical engineering comprises the art and science of power generation, the transmission of power, and transportation by mechanical devices; of the production of machinery, tools, and their utilization; and it includes research, design, development, application, and the management functions of organization, operation, maintenance, and marketing."

Hence it would follow that "the mechanical engineer is one who practices the art and science of power generation, the transmission of power, and transportation by mechanical devices; of the production of machinery, tools, and their utilization; and including research, design, development, application, and the management functions of organization, operation, maintenance, and marketing."

The field is open for anyone to criticize or revise these definitions, or to substitute his own.

What's yours?

MAXIMUM SHELL PRODUCTION

Coordination of Speed, Feed, Depth, Horsepower, Tool, and Tool Life

By M. KRONENBERG

THE CINCINNATI MILLING MACHINE CO., CINCINNATI, OHIO

THE topic of the paper I am going to read before you brings back to my memory the times of nearly twenty-four years ago. I was recalled from the trenches while serving with the field artillery in order to report at a newly built armory, where howitzers and cannon were being manufactured on a mass-production basis.

To be put in charge of a time-study department was embarrassing to me since I was not even graduated from the university at that time. In this situation, F. W. Taylor's book, "On the Art of Cutting Metals," was my rescue; through it I came first into contact with the problems which have remained the main field of my interest and research and which likewise are the subject of this paper.

It was Taylor who first realized the importance of a scientific approach to the problems of the shop. He wanted to eliminate the customary "rule of thumb" governing one of the most important branches of production, namely, the utilization and setting of machine tools.

Taylor was well aware of the difficulties involved. He wrote: "By far the most difficult and elusive portion of this work has been the mathematical side: *First*, finding simple formulas which expressed with approximate accuracy the effect of each of the numerous variables upon the cutting speed; and *second*, finding a rapid method of using these formulas in the solution of the daily machine shop practice. . . . . The best mathematicians smiled . . . . and returned the problem . . . . with the statement that it belongs distinctly in the realm of rule of thumb and could be solved only by the slow method of trial and error."

The mathematicians consulted by Taylor presented formulas considerably too difficult for practical application. On the other hand, the values in engineering handbooks and catalogs are often given with wide limits, not permitting accurate calculations. Therefore, the "rule of thumb" for setting machine tools is still predominant in the shop.

The "slow method of trial and error" as Taylor called it, must, however, be eliminated, especially today, in order to promote the production of implements of war. It is of utmost importance to furnish all shops engaged in defense work with a method enabling them to utilize quickly the results of research in metal cutting accomplished since Taylor's time.

So far, however, the data collected are not available for ready use.

Thus, it occurred to me that, if a simple system could be developed to make these data readily available for the use in the shops of this country, a great contribution would be made to the current defense program.

Such a system has been developed for the particular problem of machining shell material; it is naturally also possible to adopt this system for different materials and tool contours.

This paper presents a method for the coordination of speed, feed, depth, horsepower, tool, and tool life for maximum shell production, combining simplicity of practical application with correctness of the mathematical relationships involved. The "shell machining chart" which is here discussed is based on the best data available. They have been theoretically checked with results of investigations in this country and abroad.

The A.S.M.E. Committee on Metal Cutting Data prepared a "Manual on Cutting of Metals," which was published in 1939. In my opinion, the data collected in this book represent the best raw material to help solve our problems. They can, however, *not* be used directly owing to the complexity of correction factors to be taken into consideration.

In order to determine, for example, the cutting speed and horsepower needed for machining SAE X-1335, it is necessary to multiply values tabulated for SAE 1020 hot-rolled by so-called machinability constants.

Further factors must be taken into consideration for figuring the speed and horsepower in case of using a cutting fluid, dependent on the size of the chip. Moreover, multipliers must be used for change from high-speed steel to sintered-carbide tools, and also for changes in the desired tool life.

If one value, say the feed, is changed, it is necessary to go through the procedure again, and it is therefore difficult to see the effect of a change on the other variables. Owing to the fact that speed, horsepower, tool life, and the like do not vary proportionally, it is not easy for the men in the shop to interpolate the figures given in the Manual.

This is in no sense a disparagement of the A.S.M.E. "Manual on Cutting of Metals," as in my opinion, the abundant data compiled in this book are extremely useful, especially to all of us familiar with metal-cutting research. The Manual provides specific values for many materials, including SAE X-1335, which are not available elsewhere.

In regard to the cutting-fluid multipliers given in the Manual, only one source is quoted from which the values given have apparently been derived, namely, tests carried out by Schlesinger in 1928 at the Engineering College of the University of Berlin. It happened to be my privilege to be connected with this investigation, as may be seen from two publications on this subject.[1] It can, therefore, be stated that a single cutting-fluid factor could be used instead of the varying factors listed in the Manual.

THE SHELL MACHINING CHART

Complex formulas are not useful for the shop and seldom even for engineers if quick information is required. Tabulations, on the other hand, are usually not instructive enough since it is not possible to show the coordination of a multitude of variables. Therefore, charts are the best means to transmit results of research to the men who are supposed to use them.

The shell machining chart presented here, Fig. 1, is intended to solve the problem of the most effective combination of cutting speed, feed, depth, horsepower, tool, and tool life for the particular case of turning shells made of SAE X-1335.

It has been prepared for a common roughing tool corresponding in shape to tool No. 4, and for the use of a cutting fluid

Presented at the Third National Defense Meeting, Cleveland, Ohio, March 12 and 13, 1941, of The American Society of Mechanical Engineers.

[1] *Zeit. V.D.I.*, 1928, p. 1198, and *Maschinenbau*, 1928, p. 628.

supplied at a rate of 5 gpm as recommended in the Manual. In the case of using sintered carbide tools it may sometimes be necessary to reduce the true rake angle of the tool to about 6 to 8 deg. Then the horsepower consumption would rise approximately 4 per cent.

In the center of the chart, inclined lines are seen representing the depth of cut, ranging from $^1/_{32}$ to $^3/_8$ in.; they are plotted against a horizontal scale for feed rates of 0.006 to 0.060 in. per revolution. A second series of inclined lines with a greater slope than the depth lines indicates the shape ratios (feed to depth) ranging from 1:2 to 1:25.

A chip having a depth twice the feed rate is called a shallow cut, while a chip where the depth is 25 times the feed rate is called a deep cut. Between these limits, which are already extremes in practice, lies the normal cut with a ratio of 1:7. Most commonly used in practice are chip ratios in the range between 1:5 and 1:10. The other ratios (1:3, 1:15, 1:25) are included to facilitate the use of the chart for intermediate cases.

The left- and right-hand portions of the chart refer to cutting speed, horsepower, and tool life for high-speed-steel tools and sintered carbides, respectively.

Cutting-speed lines and horsepower lines in these fields intersect each other. The "ratio lines" for the chip shape are repeated as transfer lines in the lower left- and lower right-hand sections leading to the tool-life scales.

The chart may be used in different ways, either by beginning with an assumed feed rate, or with an assumed horsepower, or with any other variable.

USE OF THE CHART IN CASE OF AN ASSUMED FEED RATE

1 *Initial Example.* The coordination of the variables shown on the chart (see Fig. 1) is indicated by a dotted line showing a particular example using an assumed feed rate. Following this line vertically from a feed rate of 0.0175 leads to the line for $^1/_8$-in. depth of cut, and to the ratio line 1:7 (normal cut). From this point of intersection we proceed in this example horizontally to the field for "sintered carbide" until meeting the line of a selected cutting speed of 300 fpm. Reading parallel to the horsepower lines indicates that 6.4 hp is needed at the cutting edge for such a cut. Reading downward by way of the ratio line 1:7 reveals that the tool life for this example would be nine hours.

To demonstrate the effect of varying the initial variables on the coordinated values, five more examples will now be discussed.

EXAMPLES WITH CHANGE OF A SINGLE VARIABLE

2 *Decreased Feed Rate.* We want to determine now the effect on horsepower and tool life of a decrease of the feed rate to 0.014 in., keeping the speed and depth as before. Example 2 is represented on the chart (see Fig. 1) by dots. Following the same procedure, we see that the shape ratio is now between 1:7 and 1:10 since the depth is kept at $^1/_8$ in. The dot on the 300-ft speed line indicates a decrease of the required power to $5^1/_4$ hp. Reading downward by way of the dot between the ratio lines 1:7 and 1:10 we find an increase in tool life to 21 hours.

If the production in the case of the initial example is called 100 per cent, then the production will only be 80 per cent in the case of example 2, owing to the fact that the feed rate has been reduced. We need, however, less horsepower and gain appreciably in tool life.

3 *Decreased Cutting Speed.* The next problem deals with exploring the effect of decreasing the cutting speed to 240 fpm while the feed rate and depth shall be the same as initially.

Example 3 is marked on the chart (see Fig. 1) by a diamond symbol.

Starting again at 0.0175 feed rate and going up to $^1/_8$-in. depth we have the initial shape ratio 1:7. Proceeding horizontally to 240 fpm reveals a consumption of only 5 hp and an increase of the tool life to 38 hours. The production factor is 80 per cent in this case, too.

EXAMPLES WITH SIMULTANEOUS CHANGES OF MORE THAN ONE VARIABLE

4 *Decreased Feed, Increased Depth.* Example 4 is marked by cross symbols (see Fig. 1). The feed rate is reduced to 0.014 and the depth of cut increased to $^3/_{16}$. The cut ratio is now between 1:10 and 1:15. Proceeding on the horizontal line to 300 ft cutting speed, we find that the power required increases to 7 hp while the tool life would be 10 hours.

5 *Increased Feed, Increased Depth, Decreased Speed.* Example 5 embraces three changes, namely, an increased feed, an increased depth, and a decreased speed (200 ft). Example 5 is shown on the chart (see Fig. 1) by means of small circles. In this case the horsepower consumption rises to 7.5 hp while the tool life increases to 16 hr. In comparison with example 4, the production factor is 114 per cent. Thus an increase in the feed rate, combined with a decrease in speed, results in an increase in production.

6 *Increased Feed, Increased Depth, Decreased Speed, Tool Change.* Example 6 covers the case of changing four variables. In addition to the changes of example 5, we change the type of the tool by selecting new high-speed steel. The example is marked by double-cross symbols (see Fig. 1). This time we have to proceed horizontally to the *left* from the feed-depth intersection. Thus, we obtain a horsepower consumption of 3.7 hp and a tool life of 1.2 hours. The comparative production factor would be 57 per cent, since the cutting speed is decreased so much that it does not compensate the increase in feed in comparison with example 4.

USE OF CHART IN CASE OF AN ASSUMED HORSEPOWER

The specific use of the chart with reference to shell production will now be discussed.

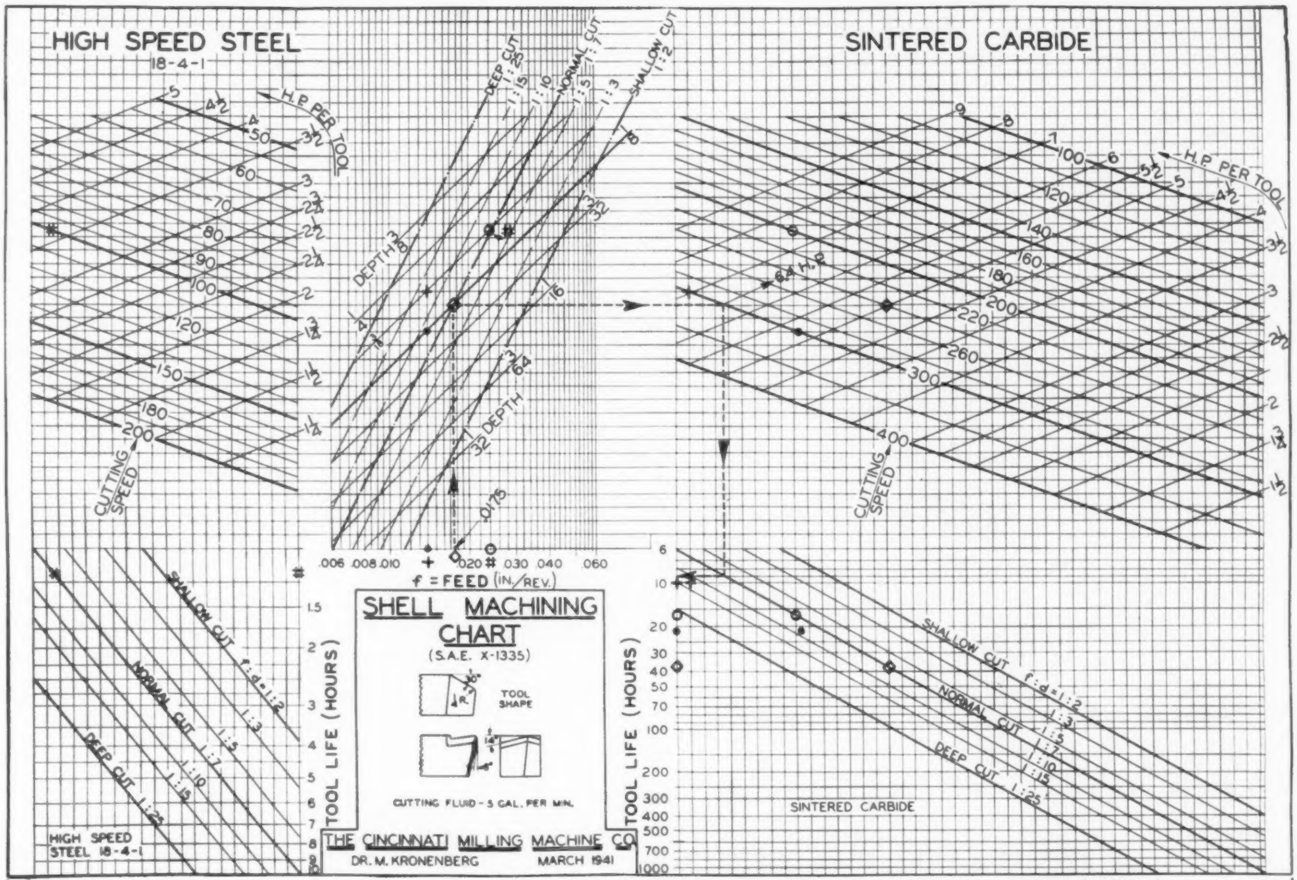
We are assuming that two different machine tools are available and that the setting of these machines for maximum shell production is to be determined. The first four examples refer to the case of a machine of 9 hp (net), the second four examples to a 15-hp machine.

Assume the following problem: We want to explore the various cutting possibilities for performing the turning operation of the outside diameter of a 75-mm shell with three tools and a depth of cut of $^1/_8$ in., as shown in the sketch in the lower right-hand corner taken from an article by Charles Graziozo in *American Machinist* of Sept. 4, 1940.

EXAMPLES OF 3 HP PER TOOL

With three tools acting simultaneously on a 9-hp machine, the power available per tool is 3 hp. The longest distance traveled is 3.55 in. The forged diameter of 3.30 in. is to be turned down to 3.05 in. (The revolutions per minute of the spindle are therefore obtained by multiplying the surface speed by 1.165.) Procedure: Tracing along the 3-hp lines in either the high-speed-steel field or in the sintered-carbide field gives intersection points with various cutting-speed lines.

Example A is indicated on the chart (see Fig. 2) by a dotted line, for a cutting speed of 100 fpm and high-speed steel. From the point of intersection (100 ft with 3 hp), we proceed horizontally to the line of $^1/_8$-in. depth of cut, realizing immediately that the coordinated shape ratio is close to 1:5. Reading downward, a feed rate of 0.027 is found, which is the proper value for setting the feed on the machine in order to exploit 3 hp per tool at 100 ft cutting speed. The correlated tool life is read vertically below the intersection of the 3 hp and



EXAMPLE NO.			FEED	DEPTH	RATIO	SPEED	TOOL	H. P.	TOOL LIFE	PROD. FACTOR	
1	--	INITIAL EXAMPLE	.0175	1/8	1:7	300	SINT. CARB.	6.4	9	100%	EXAMPLES USING AN ASSUMED FEED RATE
2	•	DECREASE FEED	.014	1/8	1:7–1:10	300	SINT. CARB.	5.25	21	80%	
3	◇	DECREASE SPEED	.0175	1/8	1:7	240	SINT. CARB.	5.	38	80%	
4	+	DECREASE FEED, INCREASE DEPTH	.014	3/16	1:10–1:15	300	SINT. CARB.	7.	10	100%	
5	O	INCREASE FEED, DECREASE SPEED, INCREASE DEPTH	.024	3/16	1:7	200	SINT. CARB.	7.5	16	114%	
6	#	INCREASE FEED, DECREASE SPEED, INCREASE DEPTH, TOOL CHANGE	.024	3/16	1:7	100	H. S. S.	3.7	1.2	57%	

FIG. 1 SHELL-MACHINING CHART: EXAMPLES FOR ASSUMED FEED RATES

100 speed line by way of the shape ratio 1:5. The tool life is 1.6 hours. One hundred and seventeen spindle revolutions are needed. Thus, we obtain a machining time of

$$\frac{3.55}{0.027 \times 117} = 1.12 \text{ min per shell.}$$

In *Example B* the effect of reducing the cutting speed to 60 fpm is considered and indicated by dots (see Fig. 2). The shape ratio is between 1:2 and 1:3, and a feed of 0.049 in. per revolution is necessary to utilize the available 3 hp per tool. Tool life increases to 4.4 hours and the production time is reduced to 1.03 min per shell.

It will again be noticed that a lower cutting speed is more favorable as far as both production time and tool life are concerned, without requiring any greater power. (This is due to the fact that the specific cutting pressure decreases with increasing chip cross-sectional area, as found in metal cutting research.) On the other hand, however, we encounter a large increase in the feed rate, affecting both the surface roughness and the cutting force. It is obvious that the forces on the machine and on the shell are increased considerably as against example *A*. Thus the tendency of the machine to deflect will increase accordingly and the accuracy of the turned shell will decrease. A calculation reveals that the cutting force is 1000 lb per tool in example *A* and 1650 lb in example *B*. Considering all 3 tools, the total force tending to deflect the machine increases from 3000 to 5000 lb. The horizontal components of this force tending to deform the shell and to dislocate it in the fixture and center increase accordingly and thus the eccentricity of the shell will increase. It is therefore important not to go to the extreme in the use of low speeds and large feeds!

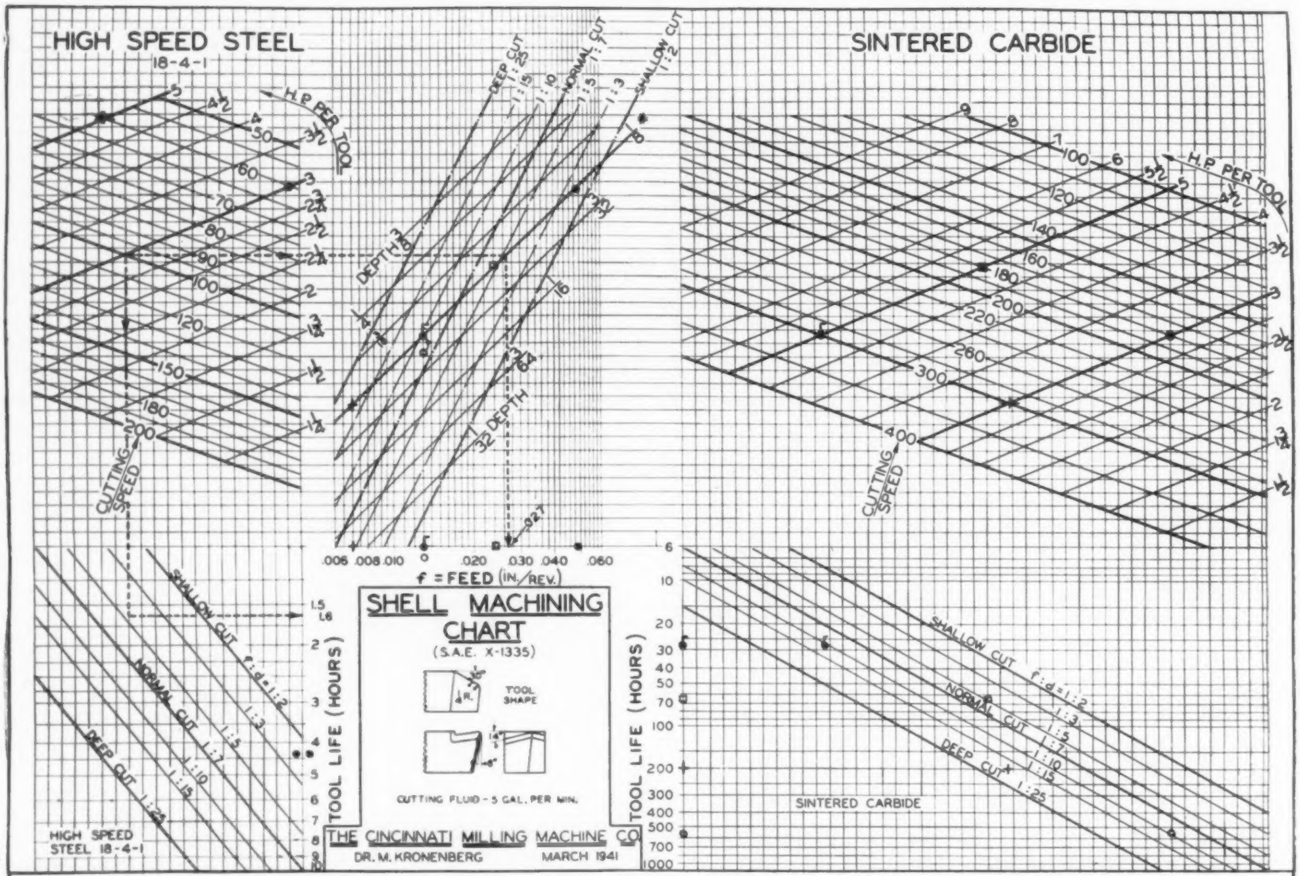
Example C is to explore the case of using sintered-carbide tools at a cutting speed of 300 fpm. It is marked by cross symbols (see Fig. 2).

It will be seen that the shape ratio is between 1:15 and 1:25 giving a feed rate of 0.007 in. per rev. The tool life is 200 hours. Machining time is 1.45 min per shell. Cutting force is only 350 lb per tool.

Example D with 180 ft per min cutting speed is marked by circles (see Fig. 2). Feed rate 0.013 in. per revolution with 550 hours tool life and 1.3 min machining time per shell. Cutting force is now 550 lb per tool.

It will be noticed that the machining time with high-speed-steel tools is more favorable than with sintered carbides, but obviously the machined surface will be rougher (owing to the high feed per revolution) and the deflection of the machine greater.

Example *B* will give the maximum shell production but the finish will probably be too rough to meet the specifications. Example *A* gives a production which is 8 per cent lower than *B*, but the finish will be considerably better. The tool life,



3 H.P. PER TOOL EXAMPLE		TOOL	SPEED	FEED	RATIO	TOOL LIFE	RPM	MACH TIME
A	---	H.S.S.	100	.027	1:5	1.6	117	1.12
B	●	H.S.S.	60	.049	1:2-1:3	4.4	70	1.03
C	+	SIN.CARB.	300	.007	1:15-1:25	200	350	1.45
D	o	SIN.CARB.	180	.013	1:10	550	210	1.30

5 H.P. PER TOOL EXAMPLE		TOOL	SPEED	FEED	RATIO	TOOL LIFE	RPM	MACH TIME
E		H.S.S.	100	X	X	LESS THAN 1 HOUR	—	—
F	#	H.S.S	60	X	X		—	—
G	winged dot	SIN.CARB.	300	.013	1:10	26	350	.78
H	▫	SIN.CARB.	180	.024	1:5	66	210	.70

EXAMPLES USING AN ASSUMED H.P. MACHINING O.D. OF 75 MM. SHELL WITH THREE TOOLS 1/8" DEPTH.

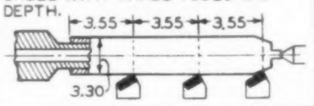


FIG. 2 SHELL-MACHINING CHART: EXAMPLES FOR SETTING A MACHINE OF 3 AND 5 HP PER TOOL, RESPECTIVELY, TO PERFORM THE TURNING OPERATION ON THE OUTSIDE DIAMETER OF A 75-MM SHELL

however, is low (1.6 hours), but this may still be satisfactory if the time required for tool changing is low.

5 HP PER TOOL EXAMPLES

The last four examples deal with determining the coordination of the cutting variables if a 15-hp machine is available, delivering 5 hp per tool at the cutting edge. The general procedure is the same as just discussed.

Example E refers to using high-speed steel at 100 ft cutting speed. It will be seen immediately that the intersection of the 5-hp line and 100 speed line is outside of the chart, thus indicating that such a combination would not give practical results. (The tool life would be only approximately 12 min.)

Example F shows the result of reducing the speed to 60 fpm and is marked by double-cross symbols. The feed rate at $^1/_8$-in. depth lies also outside of the field of the chart (that is, beyond the range of the feed scale), thus showing that it would be too large for practical purposes.

High-speed-steel tools *cannot* be considered in the 5 hp cases.

Example G for sintered carbide at 300 fpm and 5 hp per tool (marked by a "winged dot," Fig. 2) shows a feed rate of 0.013 in. per revolution and a tool life of 26 hours, with a production time of only 0.78 min.

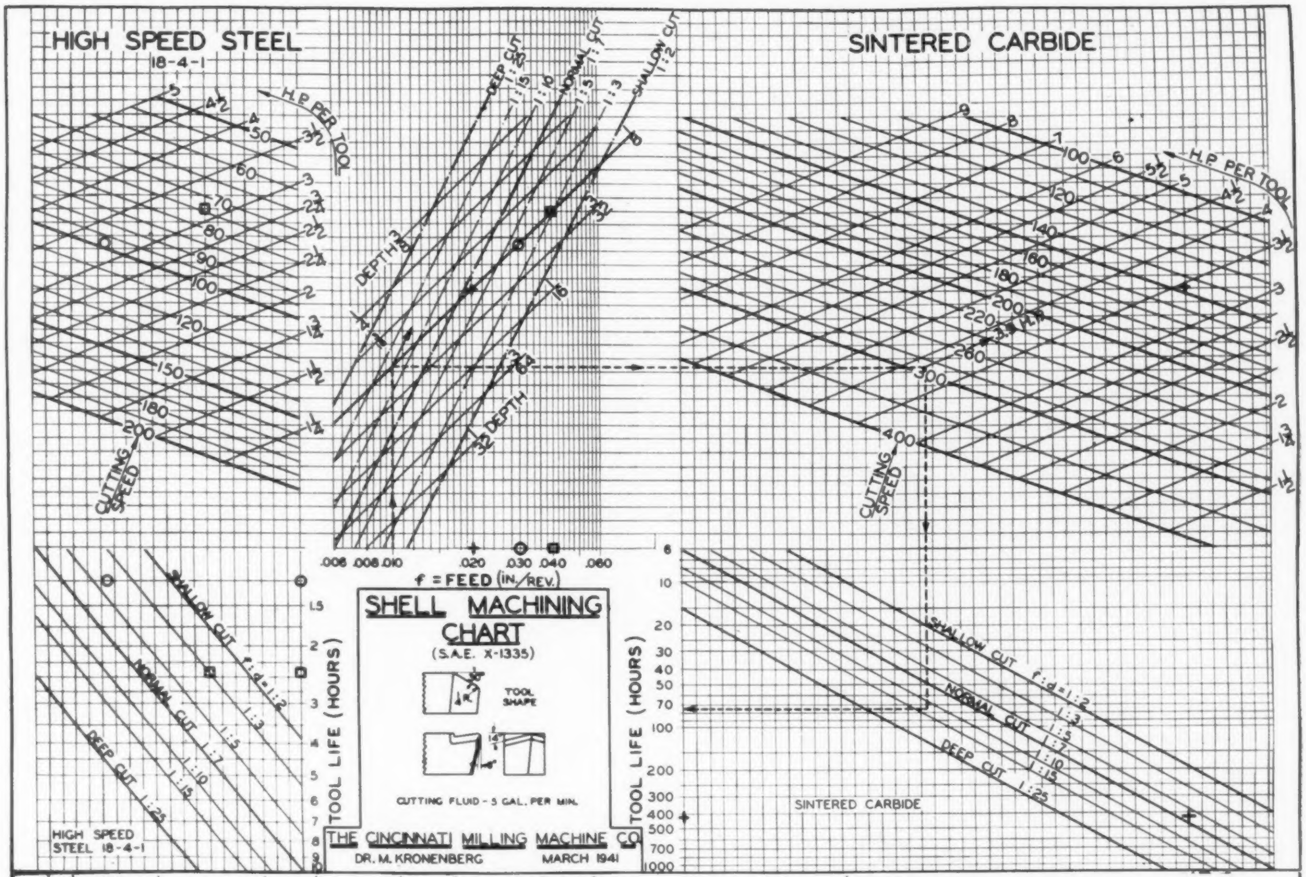
Example H, finally, for 180 fpm speed and 5 hp per tool (marked by a square, Fig. 2), gives a feed rate of 0.024 in. per revolution and a tool life of 66 hours with a production time of 0.70 min per shell. This is obviously the best result obtained in all examples. A feed rate of 0.024 is not too large involving a cutting force of 920 lb per tool. The tool life is also satisfactory.

GENERAL CONCLUSION

It is naturally not pretended that the shell-machining chart represents "the last word," but we believe that it could be useful, especially if it is employed as a basis for exchange of experience in shell machining. It might be worth-while to clear such an exchange through an office of the Ordnance Department in order to obtain values for improving the chart and to advise the manufacturers as to the latest performance figures in shell production.

From the foregoing examples it can be concluded in general that the maximum shell production depends to a large extent on the horsepower available at the cutting edge in combination with the cutting speed the tool can stand.

We have here the same basic problem as in many other lines of engineering (compare aviation), namely, to obtain maximum results by using *high* powered machines at *high* speeds, permitting *low* forces. The higher the power, the shorter the



EXAMPLE		FEED ASSUMED	SPEED = $\frac{2.94}{f}$	R.P.M.	RATIO	TOOL	H.P./TOOL	TOOL LIFE
a	--	.010	294	344	1:10–1:15	SINT. CARB.	3.9	75
b	+	.020	147	172	1:7–1:10	SINT. CARB.	3.4	420
c	O	.030	98	114	1:3–1:5	H.S.S.	3.25	1.1
d	□	.040	73.5	86	1:3	H.S.S.	3.2	2.4

$$t = \frac{L}{f \cdot n} = \frac{L \cdot D \cdot \pi}{f \cdot 12 \cdot V} = \frac{.262\ L\ D}{f \cdot V}$$

THUS $V = \frac{.262\ L\ D}{f \cdot t}$

WITH $L = 3.55$, $D = 3.28$, $t = 1$

$V = \frac{2.94}{f}$

EXAMPLES USING AN ASSUMED MACHINING TIME OF ONE MINUTE.

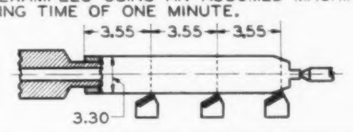


FIG. 3 SHELL-MACHINING CHART: EXAMPLES FOR SELECTING AND SETTING THE REQUIRED MACHINES IF THE TURNING OPERATION ON THE OUTSIDE DIAMETER OF A 75-MM SHELL IS TO BE TIMED WITH PRECEDING OR LATER OPERATIONS

production time; the power should be utilized by a speed high enough to permit reasonably low feed rates with relatively small forces and deflections; the feed rate should, however, not be too low, since the production time would be increased in this case as can be seen from the foregoing examples.

These examples indicate that sintered-carbide tools will be useful on high-power machines since they permit the required cutting speeds, thereby keeping the feed rates within reasonable limits. On the other hand, high-speed-steel tools are preferable in the case of the many low-powered machine tools immediately available in many small shops all over the country, the owners and operators of which are as eager as any of us to participate in the defense of America.

APPENDIX

A third chart (see Fig. 3) has been prepared referring to the machining of 75-mm shells. The examples deal with the case that a certain machining time, say 1 min, is prescribed.

Such cases may occur in a production line if the operation of turning the outside diameter has to be timed with preceding and later operations. The proper setting of speed and feed and the selection of the required machine is investigated and also the resulting tool life determined.

In this case a simple calculation must precede the use of the chart. We have to find at first the relationship between speed and feed for obtaining 1 min machining time. This is derived in the following way:

Let t = machining time, min
L = length of cut, in. (= travel per tool)
f = feed, in. per revolution
D = diameter of work piece, in.
v = speed, fpm
n = rpm

Then

$$t = \frac{L}{f \cdot n} = \frac{LD\pi}{f \cdot 12 \cdot v} = \frac{0.262\ LD}{f \cdot v}$$

If $t = 1$

$$v = \frac{0.262\ LD}{f}$$

And if $L = 3.55$ and $D = 3.30$

$$v = \frac{2.94}{f}$$

We see that the product of speed and feed must always be 2.94 in this case for a machining time of 1 min. We may assume any feed and calculate the corresponding speed, and vice versa. Four examples, ***a***, ***b***, ***c***, and ***d*** have been worked out on Fig. 3, and the results are tabulated at the bottom of the chart.

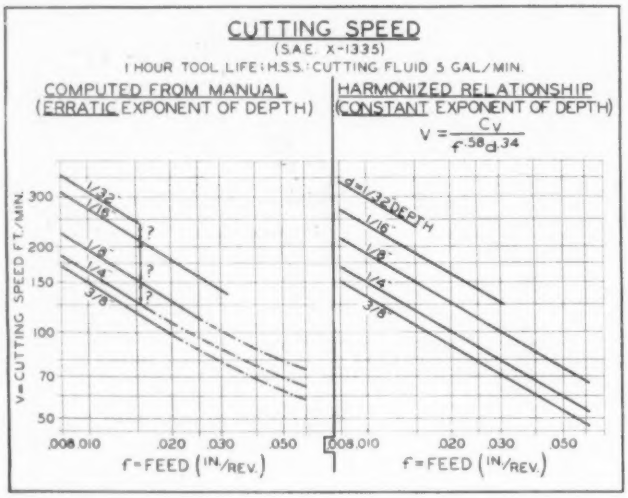


FIG. 4 COMPUTATION OF CUTTING SPEED FROM MANUAL

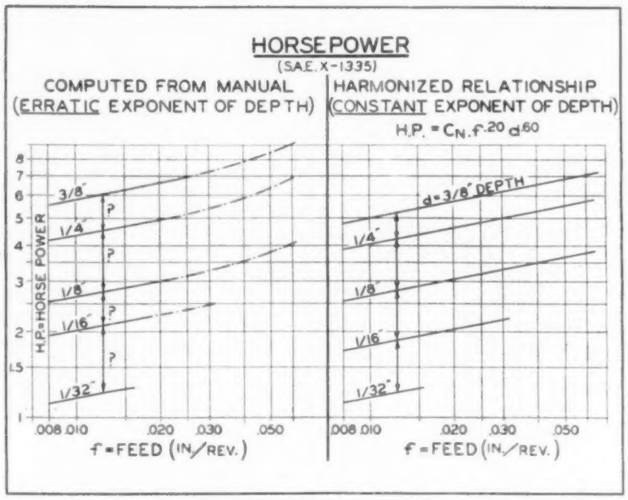


FIG. 5 COMPUTATION OF HORSEPOWER FROM MANUAL

In all these cases the machining time would be 1 min per shell. The most advantageous case is example *b*, giving 420 hours tool life with a feed rate of 0.020 producing an adequate surface. A machine must be selected or an available machine must be rebuilt to permit 172 rpm and 3.4 hp per tool at the cutting edge. Sintered-carbide tools must be used.

THEORETICAL COMMENTS

It may be of interest to discuss briefly some scientific relationships concluded from the Manual. Plotting the cutting speed values computed from the Manual for SAE X-1335, 5 gpm cutting fluid, high-speed steel, 1 hr tool life, on double logarithmic paper gives the diagram shown at the left-hand side of Fig. 4. It will be noticed that the distance of the lines representing the depth of cut is erratic (as indicated by question marks). Doubling the depth of cut from $^1/_{32}$ to $^1/_{16}$ in. shows a relatively small change in the admissible cutting speed, while doubling the depth from $^1/_{16}$ to $^1/_8$ in. would affect the cutting speed to a considerably greater extent; but further doubling the depth (or from $^1/_8$ to $^1/_4$ in.) has again a smaller effect on the cutting speed. There is no apparent reason for this and no tests known to us which show such erratic relationships. The slight bending of the depth lines indicates the effect of the variation in multipliers for cutting fluid.

It has, therefore, been found advisable to harmonize the relationship between the changes in the depth of cut and the cutting speed as shown on the right-hand side of Fig. 4; this represents the best proposition we can offer at present.

Correspondingly, the erratic relationship between feed, depth, and horsepower has also been harmonized as will be seen by comparing the left- and right-hand sides of Fig. 5.

Regarding formulas derived from the harmonized curves, it may be said that they confirm conclusions from tests with other materials and that they permit to specify the following characteristic values for SAE X-1335:

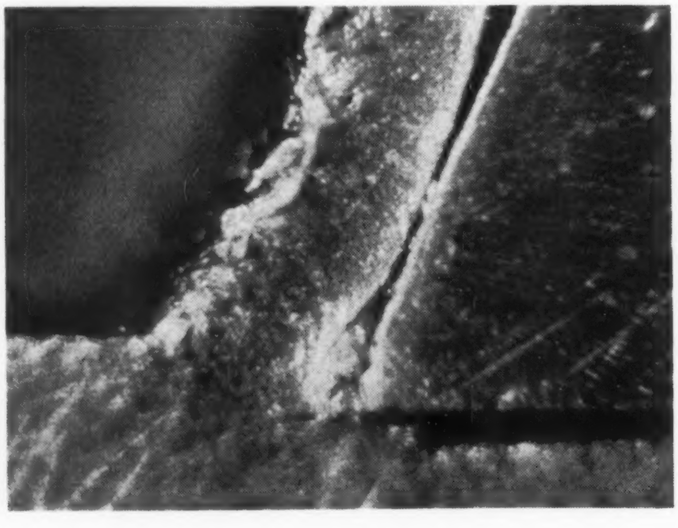
1 The admissible cutting speed for the same tool life decreases only 26 per cent if the chip shape (feed-to-depth proportion) is changed from deep to shallow, i.e., in a ratio of 1:12.5, (which is the largest change occurring in practice) but as much as 68 per cent if the chip cross-sectional area is increased by a ratio of 1:12.5.

2 The horsepower required decreases only 26 per cent if the chip shape is changed from deep to shallow, but increases 180 per cent in the case of a corresponding change of the chip cross-sectional area.

3 The cutting forces decrease only 19 per cent in case of a change of the shape by 1:12.5 as against 780 (!) per cent in case of such a change of the area.

Thus, it is obvious that the major factor affecting the relationships is the chip cross-sectional area and the minor factor the shape of the chip. The shell-machining chart takes both changes into consideration.

Chip *and* Tool



APPLYING THE RESULTS OF METAL-CUTTING RESEARCH IS EQUIVALENT TO INCREASING THE NUMBER OF MACHINE TOOLS AVAILABLE FOR NATIONAL DEFENSE

PRODUCTION ENGINEERING

An Introduction to Its Essential Factors and Principles

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THE problem of production engineering has three major phases: First, the preparation for and the starting of the production of a new product or of a major change in the design of an existing product. Second, the orderly and effective operation of the plant in the continuing production of the product. This involves minor changes in design, generally made to facilitate manufacture, together with changes and improvements in manufacturing processes and the introduction of new manufacturing processes. The problems created by changes in the amount of production, both increases and decreases, are met here. Third, the continuing and supporting activities that gather information and put it into effective form for its direct application to the two preceding phases.

Modern production today involves an almost infinite number of petty details which must be taken care of by the cooperative effort of many persons. The orderly handling of much detail necessitates setting up a definite routine for most of it. It should be remembered, however, that such routine is established to handle the ordinary, or usual conditions; unusual cases will always require special consideration. Or, to put it in other words, routine is a tool or method devised to assist us in the control of a mass of detail; yet any particular detail that can be handled more effectively by other methods should be so handled. To maintain routine, however, anyone so departing from the established routine should be prepared to prove that said departure is justified.

The essence of modern production is the breaking down of the productive effort into simple and elementary tasks, so that less skill, or rather a lesser range of skills, is required of the machine operator. To attain this end, as much as possible of the skill and technique formerly brought to the work by the craftsman must be supplied by the equipment. The further this substitution is carried, the greater are the skill and technique which must be brought to the problem by the production engineer, the machine maker, the tool maker, and the other craftsmen who design, build, and set up this productive equipment.

The many details of production engineering likewise tend to be divided into more and more specialties, so that when a task of any magnitude is to be done, a large group of specialists must be organized to handle it. When time is the important consideration, as is usually the case in preparation, complete cooperation must exist between them, unless chaos and seemingly endless delays are to result. To my mind, the essentials of effective cooperation are four. First, all persons in responsible charge must have a full realization of the objectives, and the same understanding of them. Second, the cooperating persons must have some understanding of the nature, responsibilities, difficulties, and limitations of the other person's task. Third, each responsible person must be a master of his own specialized task. Fourth, and not least by any means, each responsible person must have a definite understanding of his own responsibility and authority.

It seems axiomatic that responsibility and authority are indivisible. No person or organization can justly be held responsible for conditions over which they have no control. On the other hand, any delegation of responsibility carries with it only that authority necessary to carry out the specific task assigned. The form of an organization and the resulting delegation of responsibility is often determined by the aptitude and experience of the individuals forming the group, yet certain factors of production engineering logically involve certain responsibilities, and should automatically carry with them certain controls, or authority, regardless of the detailed form of organization, if responsibilities are to be effectively met. One of the primary purposes of this text is to point out the fundamental lines of responsibility and authority involved in this maze of production-engineering activities. No claim is made that this analysis is complete, or infallible. Varying combinations of tasks may be assigned to departments and their sections to achieve equivalent results. The attempt will be made, however, to develop a logical analysis of cause and effect.

Let us start the consideration of the subject of production engineering by listing some of the more important factors of the problem, beginning with the initial preparation for production.

PREPARATION FOR PRODUCTION

1 *Functional Design*

The first essential of production engineering is to have a product to make. The initial design of this product will be called the functional design. In its development, the major objective is to make a product that will perform some function or render a definite service. Some thought may be given here to possible methods of manufacture, yet the greatest emphasis is on its ultimate use in the hands of the consumer.

This functional design may be developed in an existing plant, or it may be brought to it from some outside source. It is the responsibility of the management, assisted of course by information and advice from other parts of the organization wherever they may be found, to decide whether or not to accept this new product for production. Certain definite objectives and requirements should be set up at the start:

(*a*) Performance requirements of the product.
(*b*) Cost of manufacture.
(*c*) Quantity, or rate of production, depending upon the size of the potential market.
(*d*) Cost of preparation for production.
(*e*) Elapsed time required to start production.

2 *Production Design*

The production design consists primarily of a critical survey of the details of the functional design. These should be changed when necessary to facilitate their manufacture with the equipment that is, or may be, available. It includes the setting of tolerances or permissible variations in size of the many elements

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This paper provides an outline of the principal factors involved in the field of production engineering and will constitute the introductory chapter of a book on this subject to be published by John Wiley and Sons, Inc., by whom permission for its use in the present form has been granted.—Editor.

of the component parts; the selection of suitable materials; the simplification of the design wherever possible; and the use of as many existing standard parts and elements as possible. Indispensable as is the functional design, it is the effectiveness of the production design that largely determines the commercial success or failure of the new product.

It is, or should be, the responsibility of the production-engineering staff, possibly a production-design group, to develop this production design. Whatever is left undone on the production design must be completed, or corrected, after production is under way. It is a process that is never finished as long as the production continues—but the major part of it should be completed before production is started. Such changes to facilitate manufacture should never require the approval of the functional designer; the authority for functional design should have the veto power over any change that would impair the performance of the product. Such objections may be raised over any proposed change, and the resulting arguments, more often than not, are differences of opinion rather than statements of fact. In case of question, it is generally possible to make simple experiments, or in extreme cases, to build a model with the proposed changes incorporated, to prove, or disprove these matters of opinion.

3 *Estimating*

Preliminary estimates are needed to guide the management to its decision as to whether or not to accept a new product, and also to set up the original objectives and requirements. A more detailed estimate is usually required after the new product has been accepted for production. Such estimates, properly made, serve as a valuable guide to the succeeding work of preparation for production and enable an increasingly larger group to work consistently toward the common objective.

Such estimating is the responsibility of the preparation group of the production-engineering staff. Records and statistics of past performances are an invaluable aid to this work. In general, these estimates give a remarkably accurate forecast of the time and money required for a given project. Too often, however, records of elapsed time, from starting to completion, of the preparation are not kept, and predictions of the actual date when production will be under way, and proceeding smoothly, are much too optimistic.

4 *Operation Layouts and Schedules*

The operation layouts are developed from the estimates, and specify the various machining operations, their sequence, machines, and tools and gages required, and the amount of equipment needed to meet a specified rate of production. This work should also include a schedule, which should take into account the elapsed time needed to design, build, and set up the special equipment. The schedule would establish the order, in point of time, in which each task should be started and finished in order that the specified date for the beginning of production would be met. At times, notes and sketches of some of the unusual features of a tool or fixture should be included to assist the tool designer in his work. In most cases, the locating and holding points on the part should be specified.

This task may also include the making of factory layouts showing the location of the equipment in the plant. The completion of these operation layouts is the responsibility of the preparation group of the production-engineering staff, and this responsibility should continue until the equipment is actually producing the parts in a satisfactory manner.

5 *Tool Design*

The drafting of the jigs, fixtures, tools, gages, and any other special equipment may be done in the tool-design department. This work should be supervised or checked by the process engineer who made up the specific operation layout. In many cases, these tool designers are specialists on tools for certain specific processes. These designers are responsible for the accuracy and adequacy of their drawings, but the process engineer in charge of a specific component part of the product is responsible for the proper selection of holding points, and the coherence of the series of tools needed to produce that part.

An increasing number of plants is reducing tool-making and tool-designing facilities to the minimum needed for maintenance of current production, so that both the tool designing and the tool making are done by outside companies. In addition, when new machines are required, the machine-tool builder is often required to furnish the machine completely tooled for a specific operation. Here the responsibility of the tool design is delegated to an outside organization. The process engineer in charge of the specific component should then make sure that the correct and necessary information is given to that outside source, since none of his responsibility has been delegated to others.

6 *Requisitions and Schedules for Equipment*

It is the responsibility of the process engineer in charge of a given component to see that orders are issued for the design and the construction of the necessary special equipment, and that schedules showing the sequence and dates when each job should be started and finished are prepared. The clerical work involved may be done in a centralized or general clerical section, but it is his responsibility to see that the section receives the necessary information, and to make sure that the clerical work has been actually done. These requisitions are based on the operation layouts. Questions of priority between the several process engineers should be settled by the chief of the section: Similar questions between the preparation group and the maintenance or production group should be settled by the general management. In this case, we have a problem of interference with routine production by the preparation for a new product, and this is a question of general policy.

7 *Checking of Tools and Tool-Made Samples*

The inspection of new tools, often accomplished by the measurement of work actually produced by the tool, may be done by mechanics and tool inspectors. These men are responsible for the accuracy of their measurements only. The process engineer is responsible for the adequacy of the results. It may be that the same inspectors are used for the checking of tools for new designs and for the routine inspection of replacement tools for the existing production. This, however, does not change the conditions of responsibility.

8 *Initial Production of New Product*

The setting-up, adjustment, and operation of the equipment for a new product may be done by the regular production force, but the process engineer who has planned this work should still be responsible for its performance until it has definitely proved itself in practice. This means that he must give this part of the work sufficient supervision so that all necessary information is in the hands or minds of the proper persons. Definite cooperation is needed here between the planner and the producer. Similar cooperation is usually needed at the very start of the planning.

9 *Checking the Performance of the Initial Assembled Product*

The acid test of the adequacy and completeness of the production design, choice of materials, and all the other preparation activities comes when the first of the tool-made parts are assembled and tested for performance. If the product assembles without difficulty, the parts interchange readily, and the assembled product meets all performance specifications satisfac-

torily, it is conclusive proof that the problem has been solved. On the other hand, if difficulty is met in any of these places, it is equally conclusive proof of incomplete planning, or mistakes, and the preparation group is responsible for these conditions, and must take prompt steps to complete or correct its work.

10 *Investigation and Correction of Initial Troubles*

Experience in the problem of starting production on a new product indicates that some diffiulties exist always at the initial stages of production. Some of them are due to ignorance or lack of the necessary special training on the part of the operators; some may be caused by misunderstandings, and lack of full cooperation between the planning group and the production group; some are present because of the incompleteness of the planning; but too often most of them are caused by definite mistakes or ignorance on the part of the planning group. The majority of changes on the part drawings in the initial days of production, most of them made to facilitate manufacture, are evidence of an incorrect, or an incomplete, production design. Unfortunately, many of these escape attention until some of all parts have been made and the first assemblies are on test. But, regardless of the cause of the trouble, the planning group should be responsible for investigating each of them and for correcting the trouble at its source. Close cooperation with the production group will prove invaluable here also.

The foregoing is an attempt at a brief outline of the more important activities involved in the preparation for production. Whether a plant is large or small, these problems will be present. In a small plant, one person or a small group may be responsible for their solution. With a large plant, a considerable organization may be required and the various problems may be divided and subdivided among several sections.

Let us now consider the more important problems of production after what is often a "nightmare" of starting difficulties is well behind us.

PRODUCTION OPERATION AND CONTROL

1 *Production Schedules and Follow-Up*

The production requirements are established by the general management, but these are usually in terms of assembled products. These requirements must be broken down, not only into the individual component parts, but also into the individual operations on each part. Schedules must be prepared for this production which will take into consideration all the other work in the plant. All these schedules must be followed up, and hold-ups and conflicts with other schedules reported if predetermined delivery schedules are to be met. Among these component parts will often be found some which are common to several of the products. These are known as stock, or standard parts. They may be made in lots without reference to the specific product orders. It is necessary, in such cases, to determine the economical size of lot to manufacture and the minimum quantity of this stock part to have on hand before starting the manufacture of a new lot. The planning and control of these details are responsibilities of the production engineer. The clerical work involved may be done in some centralized clerical department, but it is the responsibility of the production engineer to see that it is done correctly and on time.

2 *Material Procurement and Schedules*

The material required to make the product is usually ordered by the purchasing agent, but it is the responsibility of the production engineer to see that the purchasing agent has the necessary information to buy the materials required and to keep him informed of the amount needed and when it must be on hand. The amount of any specific material ordered may be based directly upon the production orders in hand, or it may be ordered for stock, as is done with standard parts, when there is any economic advantage in so doing, or if it is a critical material that may be difficult to get at short notice. Such conditions may change with time, and the whole material procurement problem may involve a question of policy which needs the approval of the general management. In this case, the detailed requirements are furnished by the production engineer, the procurement problem is stated by the purchasing agent, and the policy is established by the general management.

3 *Training of Labor*

The training of operators for specific duties is generally the responsibility of the department foremen. The actual hiring may be through a centralized employment department. Such training might well be a part of the process engineers' responsibility. The selection of persons for specific duties should be under the control of the department foreman. The majority of productive operations are relatively simple, and many of them are quite similar. For these the training and assignment of operators should cause little difficulty. In almost every plant, however, there are a few operations that require an unusual combination of skill, temperament, and integrity, and the training of such operators may become an acute problem. Hence the routine training for the ordinary operations may well be left to the foremen, but the unusual case should receive particular attention from the process engineer.

Furthermore, every opportunity should be offered to each operator to increase his skill and value to himself and to the plant. Here, a definite policy, established by the general management, and administered by some part of the production engineering staff, might be worth serious consideration.

4 *Wage Incentives*

To my mind, the most effective wage incentive is one that helps to make the individual realize, to a large extent, that he is in business for himself. Conditions are so varied that the writer doubts if any single system of wage incentive will be the most effective for any given plant. Piecework, bonus, group bonus, and many other types of wage incentives have their place.

Furthermore, wage incentives alone are not enough to secure and maintain the full active support and cooperation of each individual operator. Our concentration on the mechanical advances and refinements tends to push the human factor into the background, despite the fact that this factor is as important as or even more important than the mechanical phase.

The problem of wage incentives is one of policy, to be established by the general management and administered by the production-engineering staff.

5 *Labor Relations*

The subject of labor relations has many aspects, and many books have been written on this subject alone. Among its problems are the following: Seniority, promotion, and security; organized labor (union) relationships or individual agreements; a man's right to a job and a man's rights in his job; and the human relationships between the many individuals in an organization. All, except the last, are largely matters of policy which must be established, to a large extent, by the general management. The last, and to me the most important, is a matter of individual relationships. Improvements in these may be fostered by the management, most effectively by personal example, and self-centered and individualistic persons may be assigned tasks that do not depend on group effort; but for the most part, results really depend upon the behavior of the individuals. We should realize that some valuable potential creative ability is present in every individual of any organiza-

tion; the great problem is to develop our personal interrelationships so that this potential energy may be transformed into kinetic energy. One of my colleagues remarked, when speaking of assistance given him by mechanics in the shop: "Their field of knowledge may be quite limited, but they illuminate a small spot brightly." In my opinion, the responsibility for improving these human relationships rests with every single member of the organization.

6 *Quality Control*

The quality of any product is tested by its performance in service. Norman F. Harriman, in his excellent treatise on "Standards and Standardization," gives this definition of quality: "Quality, in the sense here used, is that which fits a product for a given use. A product is not simply good, it is good for a certain purpose, and the word quality is meaningless apart from the use in view. Good quality means good for a definite use."

Quality in a product does not develop of itself; it must be definitely and consistently striven for. The effort to achieve it must start with the original design, selection of materials, and choice of manufacturing processes; must continue through all the productive effort, including the assembling and testing; and must in many cases include adequate servicing even after the article is in the hands of the customer. An attitude of "good enough" brings sooner or later a deterioration of quality. Constant effort must be applied to the improvement of quality, always with a view to making the product better for a given use. Changes in design or in processes adopted to reduce costs should always be such as to improve the product.

Quality control during actual production requires a considerable amount of inspection. This inspection may be divided into several phases. For one, we have the preventive measures undertaken to minimize the chances of making mistakes. These include the checking and testing of materials, new tools and machines, and original setups. If the members of the production-design staff are responsible for the performance of their design, this preventive inspection will logically be their responsibility.

For another, we have the process of floor inspection as the parts progress through the several machining operations. The department foreman is responsible for the accuracy of the work produced in his department so that this inspection might logically be his responsibility also. On the other hand, if a general inspection organization exists, the foreman's responsibility should be exercised through the machine adjusters and other assistants, and the routine process inspection should be done by members of the general inspection staff. This does not mean any divided responsibility: The foreman is still responsible for results in his department, while the general inspection staff is responsible for calling to his attention any details overlooked by him or his agents, and for preventing faulty parts from proceeding further.

Following this, we have the finished-parts inspection, to make sure that only correct parts are permitted to flow through to the finished-parts stock room or to the assembly department. This is logically the responsibility of the production design staff.

After assembly, the finished product is often tested for performance, for the making of any special adjustments that may be necessary. Such testing should be logically a part of the responsibilities of the production-design staff, possibly supervised or rechecked by the functional design authority.

One advantage of having the production-design staff responsible for quality control through production is that this responsibility will keep members of this staff in constant contact with the production staff and with many of its problems; and such contact will tend to eliminate the chasm that seems to exist, unfortunately, in too many shops between the drawing room and the shop.

Such quality control should extend to a study of the performance of the product in the hands of the customers. This might be limited to an investigation of complaints from them; but for adequate product development in the future, definite studies of the performance of the product in the field will prove invaluable.

7 *Maintenance of Equipment*

The maintenance of equipment is the responsibility of the staff which uses it. The machine operator or his immediate supervisor is often responsible for reporting the need of repairs. This plan works well in general where there is a single shift of workmen; but when more than one shift is used, the equipment is likely to suffer unless there is a definite organized effort for its maintenance. The responsibility still remains with that part of the production staff which uses it.

8 *Cost Reduction*

Cost reduction efforts include the improvement and rearrangement of the equipment to reduce the productive effort, as well as the introduction of new and improved processes whenever they may become available. In the original selection and design of processes and equipment we should use the best information available. It is obvious, however, that after production has actually started, we learn much more about its unique problems than we knew before. The slogan for cost reduction effort might well be: "No matter how well we have done a job in the past, it is always possible to do it better and more cheaply." The only question is whether or not we are capable of making that improvement. This is a place where the wholehearted cooperation of the man who does the actual work of production may mean the difference between failure and success.

Cost reduction is the responsibility of the process engineer. He may be attached either to the production staff or to the preparation staff. In fact, the same process engineer may be transferred from one staff to the other, as press of work may dictate.

9 *Correction and Development of Production Design*

The initial production design is nothing more than our first best guess as to the detailed specifications of the component parts of our product that will use the available equipment most effectively, and still retain, and if possible, improve upon, the original functional design as regards its performance. If we can learn by experience, it is clear that after production has started, we should know much more about it; and the more extended our experience with it, the more we should be continually learning. In addition, the initial production design represents in general the opinions and experiences of a small group. As production continues, more and more competent persons become familiar with it. Furthermore, even with the best intentions and reasonable care, mistakes will creep in. All these conditions make it apparent that the development of the production design is a continuing process that is never finished. The production-design staff is responsible for the correctness of this design, and changes should be made without question as their need or value become apparent. If this group is also made responsible for the quality control through production, members of its staff are in constant contact with the progress of events in the shop, and this necessary information will be firsthand knowledge. Otherwise the production group must keep them informed, because a record of these developments is essential, not only to keep the records up to date, but also to have the benefits of this experience which should be incorporated into any new designs.

10 *Cost Control and Budgeting*

Without definite control, the costs of any project tend to mount alarmingly. In order to keep costs within reasonable bounds, it is necessary to be cost- and time-conscious. Probably the best way to develop this sense of time and cost is to budget the estimated amounts available. Each individual and group should then strive to accomplish its specific tasks within the budgeted allowance. If these budgets must be exceeded, it is good practice to require that requests for additional amounts, with the reasons for making them, be made before the original amount is exceeded. In other words, let each explain before the account is overdrawn rather than make excuses afterward.

It should be the responsibility of each group involved to give its own estimate, or agree to the estimate made by others, for the time or money required to carry through any project to a definite stage. These detailed estimates form part of the basis of the estimate that is submitted to the general management. From this information, the general management makes its decision, and sets up the actual budget which is to be followed.

We have now considered the more important problems of routine production. For the solution of these, and also those of the preparation for production, many supporting and continuing activities must be carried on, not all of them an integral part of production engineering, but all having a definite bearing on the problem or its solution. A list of these supporting activities is as follows:

SUPPORTING ACTIVITIES

1 *Standardization*

The subject of standardization covers so wide a field that it is difficult to know where to start. It includes the standardization of elementary parts and surfaces, materials, processes, specifications, tools and machines, and methods of test. In one respect, it is the attempt to reduce to routine as many of the elements of engineering as possible. Here, as with routine, these standards are developed to meet the normal conditions, exceptional cases will always need special consideration. Departures from such standards should always be permissible whenever it can be proved that such departures lead to better results than the use of the standards would do.

Standards may be classified under many different headings. Our general engineering standards are formulated under the procedure of the American Standards Association. The majority of our national engineering societies and trade associations have the subject of standardization as one of their major objectives. Almost every large industrial organization finds it necessary to develop specific standards for its own use; while many of them, particularly those which operate several plants, have set up permanent standardization groups in their own organizations. Practically every government department has its standardization group, and some attempt is made to correlate part of this work through such agencies as the Federal Specifications Board. In fact, the development of the production design is, in effect, the standardization of every component part of the product.

In general, any standard must stand or fall on its intrinsic merits. Any standard, to be adequate, must meet the test of utility and economy. Where an adopted standard is applicable, the chances are that in its formulation it has received far more critical study than any individual designer would be justified in giving to a single detail of design, and hence this analyzed solution available should be much better than an inspirational one that may have come on the spur of the moment.

The formulation of standards ought to be a group effort. All interests involved should be represented, the designer, the producer, and the user. The final solution should represent the best judgment of the group as to the best way of reconciling the requirements of functioning with the limitations of manufacturing processes, so as to obtain the maximum utility at the minimum expense. These standards are subject to revision and improvement as experience in their use and production makes evident the need and possibility of further development.

The responsibility for the use of standards wherever possible may be delegated to a standards engineer, but, to be most effective, a definite standards policy should be established by the general management and receive its constant and wholehearted support.

2 *Safety and Accident Prevention*

As time goes on, more and more requirements in regard to safety and sanitation are being specified by law or required by the terms of liability insurance companies. These represent minimum requirements. Some relate to the construction and use of the buildings and building equipment; some to the arrangement of the equipment, aisles, guards over open belts and gears, and some to safety features on individual machines and the attached equipment. The process engineer must do his part in the arrangement of the equipment, or factory layout, and in the design of the jigs and fixtures. The responsibility for checking these conditions may be delegated to a safety engineer on the production staff. His efforts are often checked in turn by periodic inspections of insurance-company representatives and inspectors from the state or local government.

In addition to this, there is the problem of accident prevention. This is largely a matter of individual responsibility, but much may be done by organized safety campaigns to bring his responsibility home to the individual. One plan in common use tries to invoke the spirit of competition between different departments to keep their accident records clear, or lower than any other department. Similar methods are often used to improve the neatness or cleanliness of departments, aisles, stairways, and washrooms.

3 *Manufacturing Capacity Records*

In order to plan production effectively, it is necessary to have reliable information of the manufacturing facilities available. This requires not only an inventory of the equipment but also of its actual productive capacity, as well as what part is in use on current production. In essence, it is a matter of bookkeeping, and the clerical work required may be done in an order department, cost-accounting department, or in the production schedules department.

The actual productive capacity of any piece of equipment may be quite different from its potential capacity. When a machine is used for short periods of time on successive lots of different parts, the proportion of time required for setups will be greater than when it is used continuously on a fixed setup for the production of a single part. Even in the latter case, its potential capacity is reduced by the time required to change or sharpen cutting tools, cleaning, oiling, and other items of maintenance; so that even with a full-automatic machine, the actual productive capacity may be only from eighty to ninety per cent of the full potential capacity. It is the responsibility of the process engineer to see that such information is collected and properly used.

From this actual productive capacity must be subtracted that part of it already allocated to current production, perhaps leaving a balance which is available for new work. It is the responsibility of the production engineer to see that this information is in the hands of the clerical department which is charged with the responsibility of keeping the records. These records are used by the preparation group in planning new

production and by the production group in scheduling current production.

4 *Factory Cost Accounting*

The question of purposes and methods of factory cost accounting is a highly controversial one. The accounting for direct labor and direct material costs is relatively simple, but the equitable distribution of the many indirect expenses is, in general, an unsolved problem. It is safe to say that few, if any, large organizations know accurately their true detail costs. As regards the financial accounting, particularly when a single specialized product is involved, this may be of minor importance; but for the cost-reduction engineer, and the production engineer, this condition at times is serious, because a change is often made to reduce costs, possibly a rearrangement of equipment, which reduces the indirect expense, but because of the method used to distribute this expense, the actual saving is not directly reflected in a reduced-cost record of the part in question. It should be possible, however, to so arrange the cost accounts to serve both the needs of the financial department and the needs of the production department.

Cost-accounting procedure is usually set up by the financial branch of the organization. The information used comes from many sources, including some of the production records. The preparation group has need of considerable statistical information from these accounts to prepare estimates on new products intelligently. The production group should have current and prompt reports from these accounts to know how well it is meeting its budget. The production group is responsible for the accuracy of the information which it sends to the factory cost-accounting department for record.

5 *Time and Motion Study*

Time and motion study is a tool used for many purposes, and many books have been written dealing with its technique and use. It may be used to establish a base for an incentive wage payment on some new or altered operation; or as a study to check the effectiveness of new or old equipment; or as a study toward the start of an improvement in an old process or arrangement of facilities; or as a test of the skill and increase in skill of one, or of a group of workmen. The results should serve both the production group and the preparation group. The responsibility for this work rests with the process engineer, who may be a specialist in this particular task.

6 *Labor and Equipment Studies*

In too many plants, the accuracy of the work normally produced is a matter of hope rather than of definite information. Many tolerances are established on the assurance of the production department that they can be readily met, which later must be increased materially to suit the actual conditions. One of the responsibilities of the process engineer should be to make a definite study of the limits of accuracy actually attained under the different conditions of operation, and of the degree of skill required of the machine operator as the requirements become more exacting. The preparation group should have a definite table of tolerances which can be maintained on the different types of equipment, and should be given some intimation of the increased care and skill to be exercised by the operator when smaller tolerances are specified. The effort to meet these smaller tolerances will add to the cost. These studies might also include ways and means of training operators to increase their skill. With these studies should be included a tabulation of exact sizes and forms of those elements of the equipment which govern the design and size of fixtures and cutting tools.

7 *Basic Factory Planning*

There are many incidental problems connected with any plant layout, such as provision of steam, gas, water, compressed air, or electric power. If special lines must be installed, and connected to some distant source for each new or changed layout, the expense and time may be considerable. There is always the possibility of making basic, or standard factory layouts such that any of these installations will follow a general basic plan, with provision for additional outlets near where they may be needed in the future.

In general, there are two arrangements which may be used to locate the machinery in a plant: First, the grouping of similar types of machinery together; second, the arrangement of the machines in the sequence in which they are needed to machine a specific component part of the product. The first arrangement is often used when the parts of the product are small, and their transportation from department to department does not create a major traffic problem. The second arrangement is often used on large and continuous production of heavier parts. Here we must often treat our parts- and materials-handling problems as a major task. Here too, some general basic plan as a guide will lead to economy and more consistent results.

All these and many other basic details of factory planning could well be the responsibility of the plant engineers' group of the production department. These basic plans, coupled with definite suggestions for the solution of specific problems of the plant engineer should guide the process engineer in his arrangement of specific shop layouts.

8 *Process Development*

The unique requirements of some part of the product may require the development or the material improvement of some manufacturing process. Again, the success of a new product may be largely dependent upon the development of a new process for certain critical operations. The reverse may also be true—the development of a new process may make possible the development of a new product. In addition, we have always with us the problem of finding better ways to do old jobs. Sometimes the expense of producing some part of our product leads to a search for new and improved methods, involving the development of new processes to meet these needs. Such work may be done intermittently by a specially organized group attacking a specific problem. In some plants, a definite organized effort is being made continuously to improve existing processes and to develop new ones by a permanent group. This is a part of process engineering, and should be a responsibility of the preparation or experimental group. It should never be a responsibility of the routine production group because routine production and experimental work do not mix, but rather interfere with each other.

The solution of such problems often requires research and experimenting. A laboratory solution may be found, which must next be translated into an experimental factory process, and finally be introduced into the plant as a routine production process. Care must be taken that such new processes are not forced too soon into the production routine, else the production will become too deeply involved in experimental problems, and the production schedule will suffer.

9 *Product Development*

Any product, in order to maintain a high quality, must be constantly improving. Many large organizations have research laboratories, and a large part of their work is directed toward product development; improvement of the present product and the development of new products. This is particu-

larly true of those industries which had their genesis in the laboratory. This does not imply that all of the work in such laboratories is directed for, and dictated by, commercial motives. Yet even if the commercial exploitation of discoveries is only a by-product, nevertheless these by-products, in the long run, must support the laboratory if it is to continue to operate. The work of such research laboratories may be entirely outside the field of production engineering, but eventually the results of some of this work become part of production engineering, passing through the hands of the functional designer and the production designer.

Some plants, in addition to research laboratories, have experimental departments. New and improved products are here devised, often a dozen of them for every new product which is adopted for production. Such experimental work is often a part of the problem of functional design.

Besides this, there is a large amount of analytical work, including the critical analysis of many elements of mechanism, such as gears, cams, linkages, mechanics of materials; information and analyses which are invaluable to both the functional design and the production design, but most essential to the full completion of the production design. Such analytical work could well be a responsibility of the production design.

There are two types of design which, for want of better terms, we will call the inspirational and the analytical. Inspirational design alone will give us many new things to think about, but the results will not always be practical, or of any great commercial value. Analytical design alone will give us valuable and practical results, improving quality, reducing costs, and extending the field of usefulness of existing types of products, but it will seldom, if ever, give us anything startlingly new. The best results require the inspirational features tempered by the cold reasoning of the analytical investigation.

One of the tasks for which it is most difficult to budget the time, and keep within the budget, is the design of a new machine. One reason for this is that the designer too often tries to introduce a large amount of new development with the specific task of combining a group of mechanical elements to give the prescribed service. Such specific design should be rigidly divorced from any attempts at new developments of common elements. The designer should restrain himself, and use tried and proved elements whenever possible. The problem of development is another task and should be solved by itself, and should most often be restricted to the study and development of specific mechanical elements, rather than to complete mechanisms from the start. In other words, standards should be developed for all of the more usual elements of a given type of product, and these standards should be used.

10 *Performance in the Field*

As noted before, the acid test of any product is its performance in the hands of the customer. Despite this, it is surprising how many designers of some products know practically nothing of its actual performance in the use and misuse it receives at the hands of the customer. True, he may be familiar with the conditions and results of tests made in the manufacturing plant before shipping; but many designers of printing presses, for example, know little or nothing firsthand about the problems of make-ready, operating, and cleaning a press as a matter of daily routine. Again, the unguarded remarks of a typist about some feature of a typewriter with which she was struggling might cause the ears of the designer to tingle. We too often assume that in the absence of specific complaints, everything is satisfactory. We might have the young child of a friend visiting us, whose conduct and manners were anything but satisfactory, but only in extreme cases would we complain.

It should be the responsibility of the product-design authority to either establish permanent contact with the users of their product, or to make periodic surveys of its use in the customer's plant. Here is by far the best research laboratory for the collection of performance information that exists. A relatively small amount of money spent for traveling expenses can reveal more pertinent information than many times that amount spent in setting up and operating an experimental department to uncover the same information.

Thus the problem of production engineering begins and ends with the product. Our designs, plant, equipment, organization, and all our activities are only means to this end—that we can place in the hands of our customers a product that will steadily and dependably render him some service he wants or needs.

MEN AND MACHINES AGAINST TIME

(Row of honing machines in the cylinder assembly line at Wright Aeronautical Corporation.)

ENGINEERING DEFENSE TRAINING

By ROY A. SEATON

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NATIONAL defense against modern total warfare is essentially an engineering enterprise. Warfare is now so highly mechanized, and mechanized warfare is so overpowering and deadly, that troops and nations not properly equipped with the munitions of war are helpless against those that do have an ample supply of suitable equipment. Such equipment cannot be purchased upon the open market, for no supplies of it are available. First it must be produced. It is needed in such enormous quantities and its character is so varied and complex that all available facilities and man power must be taxed to the utmost for its production. Not only must guns, tanks, explosives, ammunition, airplanes, and naval vessels be made, but factories must be enlarged and new ones built and equipped; machine tools must be manufactured; new and increased supplies of raw materials must be produced; power plants must be constructed; communication and transportation systems must be expanded; cantonments, fortifications, and bases for airplanes and naval vessels must be provided; and a host of other similar activities must be carried on.

In all of these activities engineers are keymen, necessary in large numbers for efficient planning, production, and operation. Money cannot manufacture munitions, or build factories, or produce raw materials. These must be produced by workmen, who must be given necessary information, directed, and supervised. Engineers must make the plans; work out detailed designs; supervise the construction and production; inspect and test the raw materials and finished products; and perform a wide variety of other technical and supervisory services. As examples of the magnitude of the engineers' tasks in national defense, it is reported that about one out of every ten employees in the airplane-manufacturing industry should be an engineer; that 250,000 man-hours are required to design a modern military plane; that 25,000 blueprints are required for the construction of a medium-sized tank; and that the designs for a modern battleship cost five to eight million dollars and involve drawings weighing tons.

Supervision and management are exceedingly important functions of the engineers in national defense. As Dr. Harvey N. Davis, president of Stevens Institute of Technology, recently stated:

> Efficient management in industry has been the special concern of the engineer for close to half a century. Indeed most of the conscious, rational, and therefore shareable advances in modern management, as distinguished from the intuitive, inimitable successes of brilliant individual managers, have stemmed from engineers. Furthermore, in skillful management lies our best hope of maximum production speedily attained.

Such maximum production is highly essential for effective national defense, for as William S. Knudsen, director general of the Office of Production Management, has recently told us, "Nothing short of the practical limit of our available productive capacity is sufficient for the defense job we have now undertaken."

Contributed by the Committee on Education and Training for the Industries and presented at the Spring Meeting, Atlanta, Ga., Mar. 31–April 3, 1941, of The American Society of Mechanical Engineers.

EXAMPLES OF NATIONAL NEEDS

The great expansion in industrial activity necessary for national defense is illustrated by the following examples:

In a survey of the aircraft industries in New York City, in October, 1940, it was found that since 1937 the number of workers had multiplied 50 times, and it was the opinion of responsible executives of these industries that within a year the number might well be "more than three times as great as today."

A letter we received recently stated: "Wichita (Kansas) has four airplane factories in active production, three of which have government contracts. They are in the midst of a high-pressure expansion program of physical plant, equipment, and personnel. The chief engineer of one plant told me this: 'Two years ago we had 200 employees in our plant; six months ago we had 800; today we have 2200; six months from now we expect to have between 5000 and 7000 men employed.' . . . . When all factories now being extended are under full production, about 15,000 men will be employed at this location."

Messrs. Irwin and Kadushin of the Lockheed Aircraft Corporation and Vega Airplane Company, stated last December: "From the summer of 1937 until the summer of 1940, aircraft manufacturing employment in Los Angeles County (California) alone increased from 7400 to 55,000 persons. It would not be surprising if aircraft employment in Los Angeles County reached 150,000 by the beginning of 1942."

In "This Week in Defense" (Office of Government Reports) for March 14, 1941, these statements appear: "OPM Director Knudsen reported the United States and British Governments have expanded 784 defense plants in this country at an estimated cost of $2,138,000,000. . . . . Mr. Knudsen said the Army and Navy awarded defense contracts between June 1, 1940, and February 1, 1941, totaling $12,575,869,000."

This enormous expansion of industrial activity for national defense, with the simultaneous expansion in the activities of the armed forces, which also requires many technically trained men, makes necessary a very large number of additional engineers; while engineers already employed must undertake a wide variety of new and unfamiliar tasks. The normal reserve supply of fully trained and experienced engineers is now practically exhausted and the needed additional engineers are not available. Further, it is estimated that only about 8000 of the men who will graduate from engineering colleges this year will be available for the necessary replacements in industry, instead of the usual 12,000 to 14,000, because of the demands of the armed forces for these graduates.

To meet the need for technical and supervisory services in our defense effort it is necessary, therefore, to provide additional training to partially trained engineers; to train for new tasks engineers who have been doing other kinds of engineering work; and to give to men, who have had no engineering training but who have a good general education, sufficient basic information and training to make them useful as assistants

to engineers, or to enable them to perform certain more or less routine tasks commonly performed by engineers. This is the purpose of the Engineering Defense Training program of the United States Office of Education.

ORGANIZATION OF TRAINING PROGRAM

The program was organized under a Congressional appropriation of $9,000,000 approved October 9, 1940. This sum was made available "for the cost of short engineering courses of college grade, provided by engineering schools or by universities of which the engineering school is a part, ... designed to meet the shortage of engineers with specialized training in fields essential to the national defense."

The organization for handling the program was set up promptly by the United States Office of Education. A small central staff was assembled in Washington, with national and regional advisory committees composed of leading engineering educators widely distributed throughout the United States. Instruction in a few Engineering Defense Training courses began in December, 1940, and in a considerable number early in January, 1941. From that time the program grew rapidly and steadily. At the present time these courses are under way in 47 states, the District of Columbia, and Puerto Rico, while negotiations are in progress for starting the work in the one remaining state. One hundred thirty-five of the 155 to 160 eligible engineering schools are already cooperating. Approvals have been given for more than 1100 courses providing for the instruction of about 78,000 students. New courses are still being approved daily, and the program still continues to expand. Many additional courses will undoubtedly be given in the present academic year, and a large program is expected during the next summer.

Sidney Hillman, associate director general of the Office of Production Management, recently stated: "At the beginning of the defense program, ... we were very much worried that the most dangerous kind of bottleneck would result from a lack of skilled workers and supervisory personnel. We found that this latter problem . . . . deserved more and more of our attention. . . . . Now we expect that as a result of this undertaking [Engineering Defense Training] a great deal of new technical and engineering talent will soon be made available to quicken the defense program."

High-school graduation is the minimum requirement for admission to any Engineering Defense Training course. Many courses require two or more years of engineering-school training or the equivalent in industrial experience. An engineering degree is required to secure admission to some courses, and a considerable number of the trainees in a few courses already have Ph.D. degrees.

Two general types of courses are given. The first consists of intensive full-time or pre-employment courses, given usually on the campus of the engineering school and designed to fit the trainees for employment in defense industries or defense agencies of the government. By far the greater number of our students are in courses of the second type—part-time, in-service courses, for men already employed. While many of these men are not now employed in defense industries, but are fitting themselves for such employment as they continue to earn a living at other work, most of them are already so employed. By taking Engineering Defense Training courses they are fitting themselves to do their present jobs better, or to accept greater responsibilities. This upgrading of the present personnel of the defense industries and governmental agencies is a very important part of our work. Even in the short time our program has been operating, many reports of promotions of the trainees have already reached us. Many reports are coming in also concerning the employment of trainees in the full-time courses, though few of these courses have yet been completed.

EXAMPLES OF GROWING NEED FOR TRAINING

The following cases are typical examples of growing needs for this training and of the difficulties experienced in predicting these needs:

Early in the present program, officials of a shipbuilding company in the Philadelphia area reported that it needed none of this training. About a month later this company asked for such training for 500 of its men, and the company built the necessary rooms for holding the classes.

Officials of the United States Navy last fall asked that five Naval officers be enrolled in an Engineering Defense Training course in Diesel engineering. An hour later they increased the number to 50 officers. Now they are asking that this course be repeated for 115 additional officers, and that training be given in aeronautical engineering to 200 officers and in naval architecture to 50 officers.

Allan R. Cullimore, president of the Newark College of Engineering and a regional adviser for the Engineering Defense Training program, reported recently:

> The findings of the survey made about the middle of October were based upon something less than half the total defense contracts for this six-month period [July to December, 1940]. From the middle of November to December 31 something over a quarter of a billion dollars' worth of work, exclusive of shipbuilding, was allocated to northern New Jersey, and each new contract brought with it new or changed conditions. . . . . It can be seen readily, therefore, that the entire picture was and still is in a rather fluid state.
>
> Our first contact with this plan [Engineering Defense Training] led us to believe that, except in a few instances, the need was not felt or appreciated. Subsequent findings have led us to believe that these needs are definitely becoming appreciated and felt only when the letting of contracts has been made. In a word, it is difficult for a man to vision a program of expansion if no necessity for expansion has touched him in particular.
>
> A large radio-tube manufacturer stated in November . . . . that his company was doing all that would be necessary in the way of training men. By the time the defense-training courses opened this company had received orders for such a huge volume of work that they sent 60 men to us for training.
>
> Another company, manufacturing electric meters, also stated in November that the long-range company training policy could be counted on to take care of their needs, and they (later) sent about 90 applicants to us for training.
>
> The total number of applications in Region 5 [northern New Jersey] has grown to upward of 2500. About 35 per cent of these men came at the suggestion of or with the blessing of the management of their own concerns who really had pressing needs—who, because of the exigencies of national defense, needed trained men as quickly as possible. A total of 1095 men will be in training or will have been trained by the early part of April.

EXTENT OF NATIONAL NEED

Director General Knudsen of the Office of Production Management is now reported to be asking for "all-out" manufacture of munitions, ships, and planes, saying that while we cannot foresee accurately just what our needs will be, we should make *all we can*. Although much preliminary work has already been done for national defense and a considerable volume of production is now under way, the peak of our production will not be reached for many months. Figures compiled recently by the Office of Production Management show that present authorized and proposed government expenditures for defense total $39,177,800,000, while actual disbursements against this sum from the United States Treasury from June 1, 1940, through March 17, 1941, totaled only $3,452,000,000. It is apparent that our national-defense effort is only well started and an immensely greater volume of production must be accomplished.

As more contracts and subcontracts are let under the new

Lend-Lease program and our own expanding defense program, manufacturing companies will be forced to expand their plants and personnel still further and will need many more technically trained men to act as what may be called "the technical sergeants and commissioned officers of the industrial army." The companies, in general, do not have adequate facilities and qualified staffs for training these men, nor do they have the time for it. They must look to the Engineering Defense Training program for this training.

Floyd W. Reeves, executive assistant to Sidney Hillman, associate director general of the Office of Production Management, recently stated: "The United States Office of Education, the federal agency responsible for improving education of all types and at all levels, has been assigned the task of planning so that government policies affecting schools and colleges will be developed in accordance with practical possibilities for service by educational agencies and institutions. Since the National Defense Advisory Commission relies on appropriate government agencies to administer the programs which fall within their respective fields, the United States Office of Education becomes the major government agency responsible for the coordination of educational policies for schools and colleges in relation to problems of national defense."

In our all-out defense effort, the maximum volume and speed of production will depend upon some physical factor such as the amount or kinds of materials available or the capacity of plants or the number of qualified men available to operate the machines, supervise production, or manage the plants. It is the obligation of the United States Office of Education and the engineering schools to see that adequate training is provided so that a shortage of competent engineers shall not become the controlling factor in our defense production. They must make sure that defense industries and defense government agencies can obtain the necessary engineering personnel as it is needed.

AVAILABILITY OF APPLICANTS FOR TRAINING

Reports from the engineering colleges indicate that there are available large numbers of qualified students. While a few proposed Engineering Defense Training courses have had to be canceled for lack of applicants, there have been many more cases in which the demand for training has been so great that additional classes beyond those originally planned have had to be organized. A few examples may be cited:

Last fall the Illinois Institute of Technology, in Chicago, proposed to organize Engineering Defense Training courses for 491 students. There were 2000 applicants for these courses, of whom 1000 were accepted.

The University of Toledo proposed to set up seven courses for 215 students, but had over 1100 applicants and enrolled 720.

One course planned by the University of Maryland for 200 students had 1600 applicants.

The Defense Training Institute of Greater New York, organized under our program by the eight engineering colleges in that city, made arrangements to train 400 high-school graduates but received 8000 applications.

A recent Associated Press story from Berkeley, Calif., reads: "The Government-sponsored engineering defense courses offered by the University of California extension division are attracting many more persons than anticipated. At San Diego, where preparations were made to handle 100 students, about 1000 enrolled."

Splendid cooperation in the Engineering Defense Training program has been received from the engineering schools and their faculties. It is evident from reports we have received that the great majority of them are enthusiastic supporters of the program. Sample statements are:

From the University of Pittsburgh: "The courses are progressing smoothly and with surprisingly good attendance. The character of the students, their aptitude and earnestness, has been an inspiration to the faculty in charge and has in some cases changed an attitude of skepticism into one of enthusiasm."

From Rutgers University, New Jersey (course in petroleum technology): "Many important executives . . . . are not officially registered but ask the opportunity of attending."

From the University of Delaware (course in time and motion study): "Enrolled are five United States Navy inspectors, a representative of the United States Army Ordnance Department, and a representative of the Netherlands Purchasing Commission."

From Norwich University, Vermont: "The Engineering Defense Training program offers these men (the trainees) an opportunity to broaden their training by taking special courses. Attendance brings several advantages: (1) additional technical information; (2) an opportunity to learn of the experiences and practices of other engineers also attending; (3) more alertness to changes and improvements in materials and methods; (4) a stimulation to greater effort, increased responsibility, and outstanding achievement."

From Yale University: "The Connecticut program is going smoothly. The prospective students are so well selected that the 'shake down' in New Haven, for example, was about 5 per cent. Everyone is amazed and pleased with the caliber of students and their enthusiasm. . . . . It appears that Connecticut will have 2500 or more students enrolled under the Engineering Defense Training program."

GREATER PROGRAM ANTICIPATED

The Engineering Defense Training program is still so new and is still developing so rapidly that it is difficult at this time to make accurate estimates of the extent of the need for the training during the next fiscal year. It is evident, however, that there will be need for a considerably greater program than is now under way. It is evident also that the colleges can handle a considerably greater program of training next year.

The appropriation for the present program was not made available until Oct. 9, 1940. The program then had to be organized from a standing start. The administrative organization had to be set up, and procedures worked out. Needs of industries and availability of students had to be surveyed, and the industries and prospective students had to be made acquainted with the opportunities for securing Engineering Defense Training. The colleges had to plan their courses, organize their instructing and supervisory staffs, secure additional space and equipment, if these were needed, and enroll the students. The first courses in many colleges had to be organized on a somewhat tentative and experimental basis, in much the same way that the first orders for munitions from an industrial concern are considered "educational orders." After these orders are successfully completed and procedures and methods have been tested, production can be carried on much more rapidly. Similarly a much larger program of Engineering Defense Training can be handled next year than has been possible this year. Most of the eligible schools not already participating are expected to cooperate next year and the training programs of those schools already participating can be greatly expanded if sufficient funds to pay the costs of the courses are made available.

It is believed that the expanding needs for Engineering Defense Training, the splendid response of the engineering schools and students under the present program, and the enthusiastic reception given to the program by industries and governmental agencies engaged in defense activities justifies the hope that adequate appropriations will be made for a considerable expansion in the program for next year.

Planning for
ACCELERATED PRODUCTION

As Practiced by Hamilton Standard Propellers

By ARVID NELSON

FACTORY MANAGER, HAMILTON STANDARD PROPELLERS

IN common with the rest of the aeronautical industry, Hamilton Standard Propellers, has had and is having its problems of capacity, schedules, and priorities, and to date has been able to meet and at times even anticipate greatly accelerated schedules. Owing to the company's position in the industry, those of us who are associated with it got an early "feel" of the upward trend of the aircraft industry as a whole since our production requirements were substantially the combined requirements of both engine and aircraft manufacturers. This gave us reason to think and plan in quantities above any normal requirements and contributed, in a large extent, to our method of planning.

In order to have an accurate measure of the effort involved in a required task, we have for some time used a unit of production which we call an equivalent two-way propeller. This, of course, does not necessarily mean that the physical unit produced is an actual two-way propeller. It is, however, the most nearly accurate measure which we have today to determine the requirements of man-hours, floor space, dollar inventories, and number of productive and nonproductive workers.

An indication of the magnitude of the expansion which we have undergone and that which we are currently attempting to accomplish, appears in Fig. 1. This chart starts in 1938. From 1935 to 1939, a fairly constant, normal growth was maintained, but in the last half of 1939 the growth changed from the normal business growth to a steeply accelerated production. There are four basic differences between normal growth and the mushroom type of expansion. The first difference is a very rapid rate of increase at the beginning of the expansion period. The second is the comparatively short period of peak production. The third is that the volume at the peak is extremely high in proportion to the normal base. Finally, at the end of the period, which is not shown on the chart, the rate of decrease will probably be very rapid. These four differences in the two types of expansion must be considered in any planning for accelerated production.

NEW SYSTEM OF CONTROL INSTALLED

A study which was made in 1937 for the Procurement Planning Section of the Air Corps on how, in the event of an emergency, a rapid rate of expansion could be accomplished, led us to recommend, among other things, the installation of a new system of manufacturing and inspection control. The system then in effect would not accomplish the purpose because it lacked the flexibility for utilizing available material and machine-hours obtainable through multiple shifts. The rapid rate of increase at the beginning of such an expansion period, the first of the four basic differences just mentioned, made this new system almost mandatory under such conditions. The change requested in the new system was the replacement of Army source-inspected material, Navy source-inspected material, and commercially inspected material, together with their three sets of records and controls, by one group of inspected material which would be acceptable for any use. The number of forms was cut from 63 to 26. The simplification in paper work effected by this new system almost eliminated the necessity of any increase in personnel to handle adequately the increase in the ordering department as the principal factor in increasing this load is the increase in the number of designs and parts. It is obvious that this change greatly accelerated the rate of ordering materials. With the active and enthusiastic cooperation of the Army and the Navy, the change in the system was effected in 1939.

Fig. 2 shows the simplification effected by the new control system. The change made possible:

1 Quicker initial deliveries of government contracts.
2 Flexibility of schedules.
3 Availability of materials for Army and Navy requirements for all types in stock.
4 Simplification in procurement procedure.
5 Closer control of inspection standards.
6 Increased efficiency in the manufacture of propellers.

ELIMINATING PERSONAL OPINION FROM INSPECTION

The second phase of planning resulting from the rapid rate of increase was that of eliminating, wherever possible, those matters and decisions which depended upon opinion. For example, the acceptance of major parts which are highly stressed,

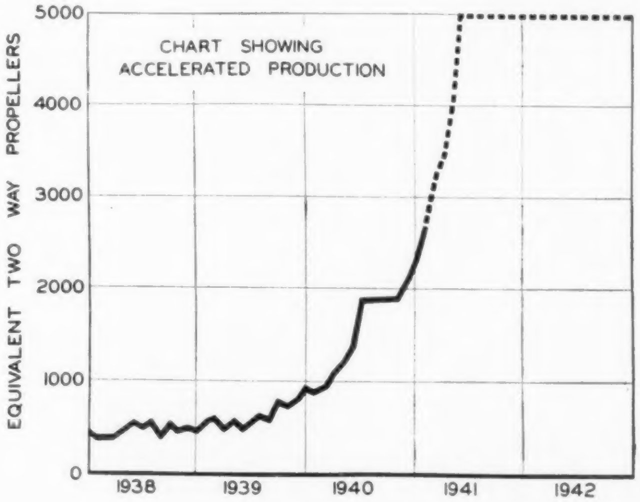

FIG. 1 ACCELERATED PRODUCTION PLANNED FOR

Presented at the Third National-Defense Meeting, Cleveland, Ohio, March 12–13, 1941, of The American Society of Mechanical Engineers.

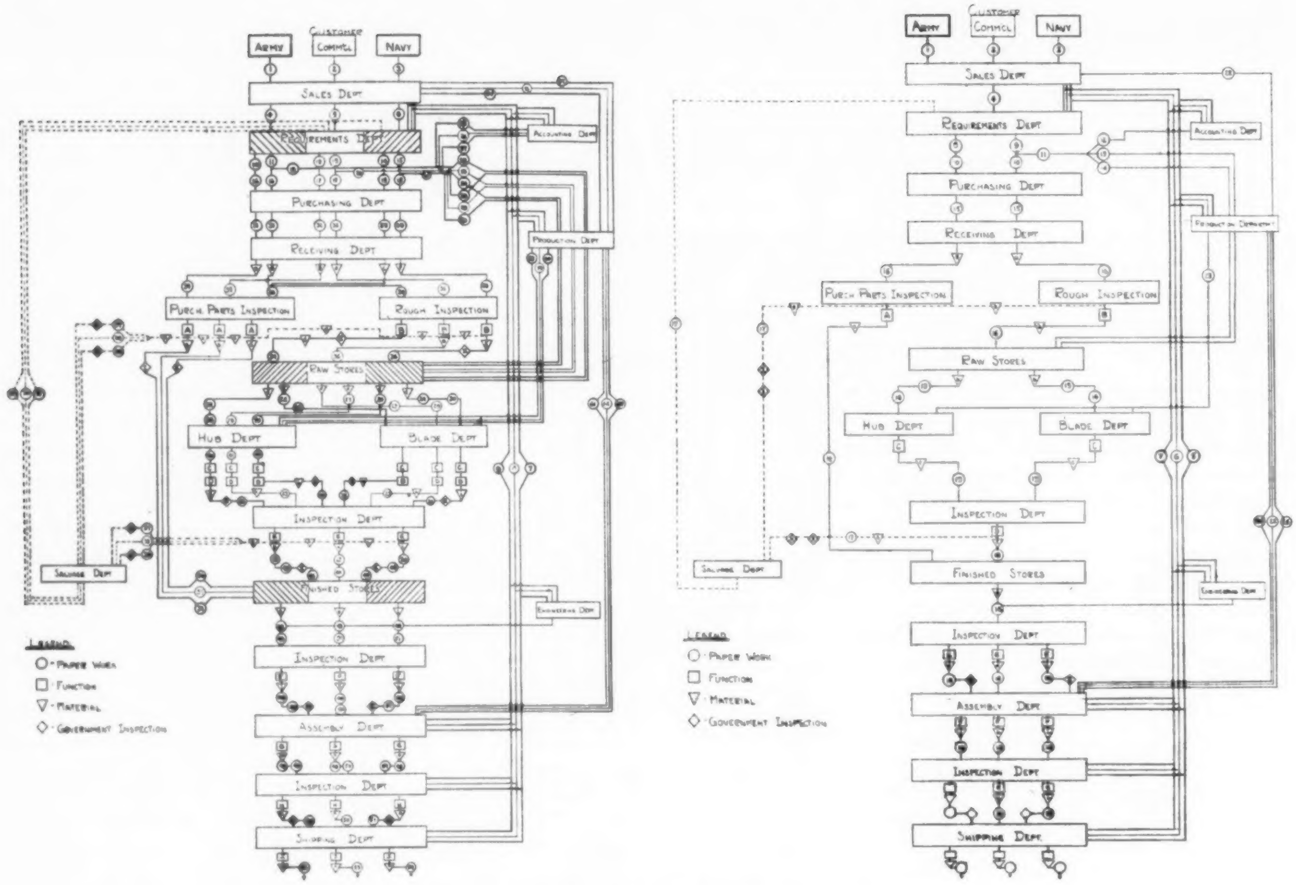

FIG. 2 SIMPLIFICATION EFFECTED BY NEW SYSTEM

and made from alloy steel, is based on the magnetic method of checking flaws—more familiarly known as magnaflux inspection. This inspection method can easily allow personal opinion as to the seriousness, location, and size of the indications to destroy all uniformity of acceptance or rejection. Our engineering department, sensing the acuteness of this particular situation, rationalized this problem and brought it down to dimensional measure and plainly determined the positions and sizes of acceptances and rejections, classified as follows, and illustrated in Fig. 3.

The following shall be cause for rejections:

I For areas subjected to high vibratory stresses ("stressed")
 A Magnaflux indications parallel (± 45 deg) to stress lines
  (1) Any indications having a length greater than $^1/_4$ in.
  (2) Any indications located less than $^1/_{16}$ in. apart in a transverse direction relative to the stress lines
 B Magnaflux indications perpendicular (± 45 deg) to stress lines
  (1) Any magnaflux indications

II For areas subject to low vibratory stresses ("unstressed")
 A Irregular, heavy magnaflux patterns having a length greater than $^1/_4$ in.
 B Straight, heavy, continuous indications following grain lines and having a length greater than 1 in.

Prior to this time we suffered rejections of from 33 to 66 per cent, which made it impossible, after having expended man and machine hours still to maintain schedules. Today, under these new specifications, our rejections have been reduced to approximately 2 to 5 per cent without impairment of quality.

Another example of a similar nature was the high finish applied to both internal and all external propeller surfaces. This had developed as a result of continuously raising the standard for finish to the point where the margin had become entirely too narrow to obtain a uniform interpretation and opinion from one individual to another. It had long been realized that, although this finish made a fine appearance, it was not necessary for the proper functioning of the parts involved. This, of course, does not mean that we disregarded what we have learned about the necessity of polished surfaces to eliminate minute scratches in highly stressed sections. Samples of the recommended finish were prepared and, with the active cooperation of the Army and Navy, were accepted and the new standards were put into effect early this year. In order that there shall be no variation in opinion among the individuals working on the various shifts, samples of the accepted finishes are available in the inspection department. Where the type and finish are such that appearance does not necessarily define the finish, a profilometer is used to establish a proper reading.

The change referred to reduced both the training time required for the new men who have been added during the last year and the number of men who have to be trained. Shortly after the acceptance of this new standard of finish we were able to transfer 44 men from our buffing department to other work. In this way we not only gained personnel when it was actually needed but also simplified our supervision problem. It follows, of course, that this change made possible a reduction in man-hours required and, likewise, reduced the required amount of supplies such as buffing wheels, emery cloth, and polishing paste. This latter reduction would, of course, be of small consequence in normal times, but under today's demand

probably means less restriction, to some extent, on commercial requirements for these types of supplies. A further advantage of the change was the increase in the rate of flow of work through the shop. This all meant that the cost was reduced and, as a result, we made price reductions in open contracts.

SOURCE OF SUPERVISORY PERSONNEL

In the procurement planning study made in 1937 we stated that our then personnel would provide the nucleus of our supervisory force in the event of an expansion. Fig. 4 shows there is a comparatively short period for the peak. As a matter of fact, we have never yet reached that peak. This chart clearly shows that we no sooner reach an objective than it is swallowed up in a new endeavor. In fact, three times the new schedule took effect before the previous one could be completed. Therefore, the peak is expected to be of short duration so that whatever additional men or equipment are to be used will be used for only a comparatively short time. For this reason, we draw almost all of our new supervisors from the ranks of existing personnel in order to avoid employing outside supervisors whose period of training might well be sufficiently long to make them of little use by the time the peak load is over. With this in mind, an organization chart was laid out for 117 supervisory jobs. A survey of the available personnel was made, as well as a study of the qualifications for each job. With one exception, every supervisory job of any importance at all was filled by our own people. Within the last 12 months, every one of these supervisors has been promoted by enlarging the scope of his previous job, by giving him an equivalent job on a better shift, or by transferring him to a job with more authority and responsibility. All three types of promotion are followed with a commensurate change in rate.

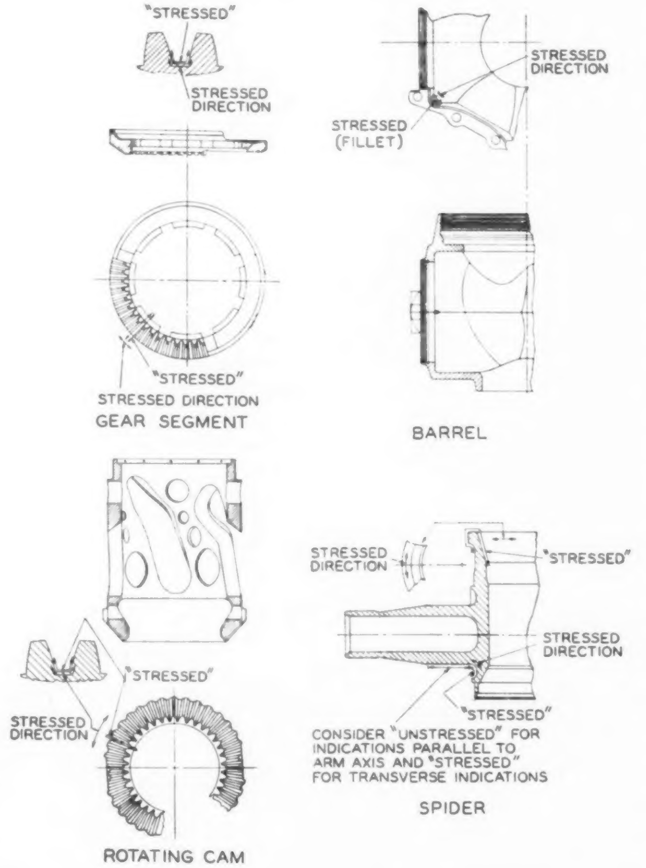

FIG. 3 SAMPLE MAGNAFLUX SPECIFICATIONS

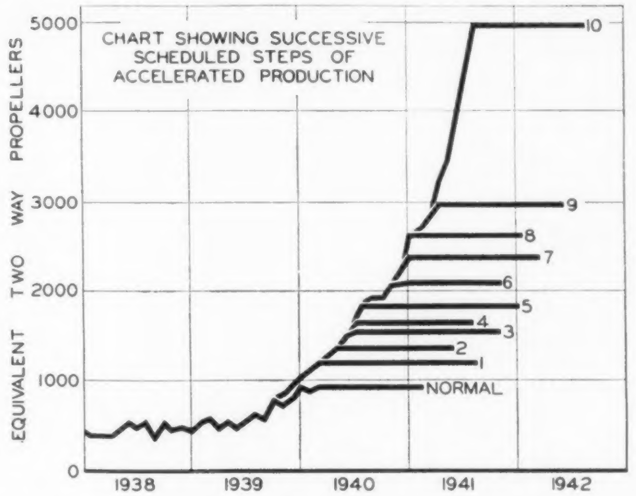

FIG. 4 SUCCESSIVE SCHEDULED STEPS OF ACCELERATED PRODUCTION

Obviously, not all of these supervisory positions could be filled with men having previous supervisory experience. To meet this situation, a training program is being conducted. The foremanship discussion group method, as developed by the National Metal Trades Association, has been successfully used by us before. We are therefore using the same method for the training of both our new and our promoted supervisors. It is believed that this policy, although it does not necessarily produce the best supervision that could be bought, does provide an invaluable morale and loyalty to the company which no money can buy.

A further result of the apparently short period of the peak is the use, in certain instances, of second-hand equipment. It is sometimes possible to obtain, at comparatively low cost and quick delivery, second-hand equipment which will be adequate for short-term use. Such equipment, of course, is not used for precision work or, in the case of office equipment, for permanent installation.

NEW METHODS ADOPTED

The third difference in the characteristics of the expansion curves was that the volume in the accelerated production reached a peak which was extremely high compared to the normal base. This difference makes it almost mandatory that new methods be found. Wherever possible, the method used, whether it was manufacturing, clerical, or supervisory, was simplified. The simplification of manufacturing methods was accomplished, wherever possible, by the acquisition of single-purpose, high-production, accurate machine tools. By this means we reduced the requirement for floor space, for skilled labor, and for the number of machine tools. The increase in volume allowed us to arrange our equipment in functional lines. Further development of the same idea led us to install conveyer lines which again reduced the requirement for floor space, reduced the amount of materials-handling labor, and simplified the job of supervision. We do not limit this policy of simplification to manufacturing operations. It is extended to all our overhead departments. A request for an addition to overhead personnel is frequently resolved into a simplification of the function for which additional help was requested. For example, this expansion has obviously increased the load in our personnel, tool-engineering, and ordering departments. Instead of expanding these departments in the same ratio as the load, advantage was taken of the increase in volume to simplify the systems and to procure mechanized equipment. The result of this philosophy is shown in Fig. 5. This is an

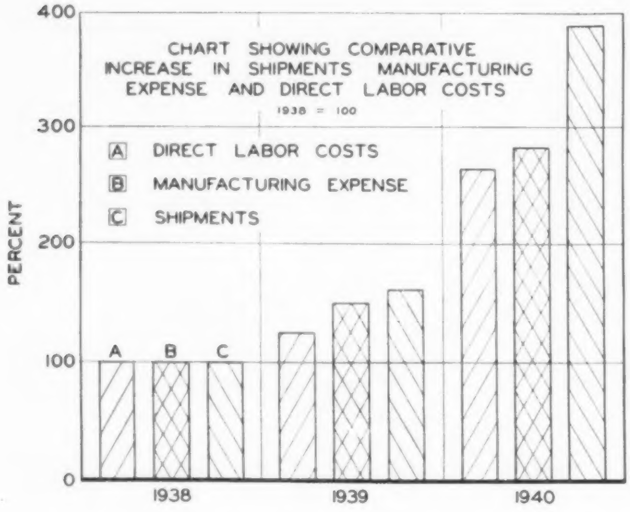

FIG. 5 COMPARATIVE INCREASE IN SHIPMENTS, MANUFACTURING EXPENSE, AND DIRECT LABOR COSTS

index chart with the year 1938 set at 100 for shipments, manufacturing expense, and direct labor. It shows that in 1940 the shipments were almost quadrupled over 1938 while the manufacturing expense was less than tripled and the direct labor was increased even less than manufacturing expense.

ADVANCE PLANNING FOR DECREASED RATE OF PRODUCTION

The fourth difference, although not shown on the chart, is, perhaps, one of the most far-reaching influence, namely, the rapid rate of decrease at the end of the expansion period. This condition was recognized early in our planning and, through various discussions, the following policy was adopted.

The expansion in our present plant should proceed only to a point where no more labor was available within comfortable commuting distance. We would then let the additional expansion be located where there was an available surplus of both plants and labor. This was done in order that there should be no disintegrating effects of mushroom growth in the community in which we are permanently located. We further decided that on some of our major parts which, by the way, are manufactured to a close tolerance and can be produced accurately and economically only on semispecial equipment, we would locate satisfactory subcontractors. In assigning subcontracts, we chose well-established firms whose volume of business was substantially less than it had previously been; who still had, intact, a good supervisory force accustomed to working to close tolerances; and who had available the necessary floor space for the installation of the type of equipment required. Such concerns, of course, had in existence as well the necessary plant facilities such as a maintenance department, storerooms, cribs, an accounting department, and general office help. When it became evident that our load would further increase over our then contemplated schedules, so that no time should be lost, we placed orders for special and essential equipment before contracts had been received for propellers and before subcontractors had been selected for parts.

These steps made it possible to spread part of the load over many widely scattered communities, all of which were eager to participate in this work. In none of these communities is this additional load expected to be sufficiently large to raise any unusual problems after the expansion period is over.

Following out this plan, we have established what we call an assembly plant. It is here that a large portion of our present schedules will be executed. In this plant will be assembled propellers whose parts, with the exception of blades, will have been principally made by subcontractors. This plant is located in a community that otherwise would have hardly felt any of the effect or reflections of increased pay rolls directly connected with the present defense program. This plant, a textile plant, idle for years, was reconditioned and made suitable. The rent will help its owners to provide carrying charges. It will again give to those people, who perhaps became unemployed at the time this plant shut down, an opportunity to be gainfully occupied.

Following this plan of renting a plant for the manufacture of blades and assembly only, we increase the percentage of all material, including subcontracted parts, from approximately 58 per cent in our own plant to 75 per cent in the rented plant. See Fig. 6.

PLANNING METHOD WORKED OUT

From the foregoing planning doctrine, a definite planning method was worked out in the following manner. When an increase in output is required, it is first necessary that a specific schedule be issued showing by actual design numbers how many assemblies are required and when they are required. This assembly schedule is then broken down into parts and a decision made as to what subcontracting policy will be followed. The parts to be manufactured are then broken down into a series of operations and the existing equipment machine loaded on a three-shift, six-day-a-week basis. Equipment which had previously been acquired for normal operation, that is to say, two shifts five days a week can, of course, produce approximately two thirds more by manning it in three shifts, six days a week. At this point, a rule of thumb can be formulated that all equipment must have a production rate of a definite quantity per hour, or to put the same thing another way, there is a limit set on the longest operation permissible. This can be determined from the original assembly schedule after making a suitable adjustment for spares and scrap allowance.

The results of the machining loading study will fall into three general classifications. The first will consist of operations with a large overload, that is to say, more than 100 per cent. This overload necessitates finding a new method of performing the operation because, unless this is done, at least two machines, exactly like equipment on the floor, must be ordered. Overloads ranging from 25 per cent to 100 per cent are frequently solved by duplicating equipment, although an improvement in tooling can sometimes accomplish the desired result. Overloads of less than 25 per cent seldom are met by procuring additional equipment since it is usually possible to find some means of improving operations, tooling, or methods by that amount.

On the basis of this study, purchase orders are issued for new equipment. It should hardly be necessary to point out

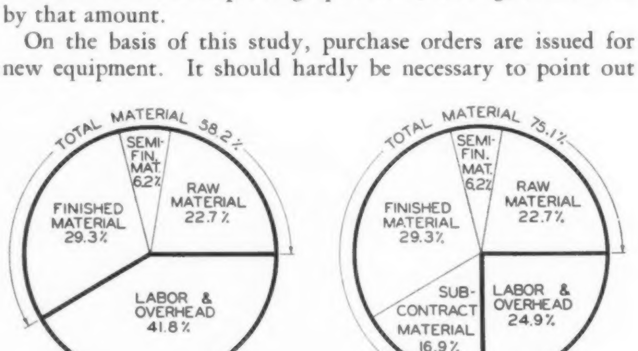

FIG. 6 COMPARATIVE DISTRIBUTION OF EFFORT IN MANUFACTURING PROPELLERS IN HOME AND RENTED PLANTS

that the study is directed so that the bottleneck equipment is ordered first.

As the equipment is ordered, a machinery schedule, based on the manufacturer's quoted delivery date, is drawn up. This schedule is checked against the objective—the original manufacturing schedule—to make certain that the equipment will be received in time. Of course, this does not always happen. When the machinery schedule shows that a particular piece of equipment is going to be late, efforts are made to improve the machine delivery. Failing this, arrangements are made to have a substitute means of performing this operation, usually at an increased cost to be sure, until the ordered equipment can be delivered.

From the original machining schedule, a schedule for hiring men is established. This is set up by determining the trend in efficiency of each manufacturing department and forecasting the probable efficiency at the time the schedule reaches its peak. The period for training new employees is known and varies from two weeks to four months, depending on the type of operation being performed. A hiring schedule for direct labor is established by working back from the increased manufacturing schedule, a time necessary to train the new employees. This direct labor can be spread almost equally over three shifts, if the machine planning outlined has been properly carried out. Ideally, although we all know it is not practically possible, each operation for each part would be of equal length. The degree to which this ideal is obtained can be measured by the distribution of direct labor over each of the three shifts. Ours is currently in a ratio of 35-34-31. The ultimate in balance of men on a three-shift basis would be $33^1/_3$.

The amount of indirect labor necessary is determined as a percentage of direct labor. It will be noted that, if a straight percentage ratio is used, an assumption is made that the gain in efficiency of indirect labor will be equal to the gain in efficiency of direct labor. We therefore reduce the percentage allowed for indirect labor which obliges our supervisors to manage their indirect labor more efficiently. From this reduced percentage a hiring schedule can be made for indirect labor. These two schedules are then added together and constitute a hiring schedule for the shop. A check on the accomplishment of this schedule is made every two weeks.

This method has two outstanding advantages. The supervisors know, well in advance, the training load which they will have and the personnel department knows equally well in advance the number and kind of people it will have to hire. From a study of these hiring charts can be determined not only

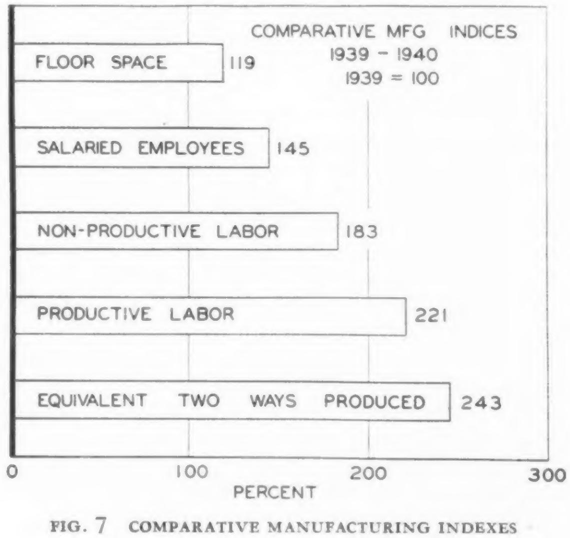

FIG. 7 COMPARATIVE MANUFACTURING INDEXES

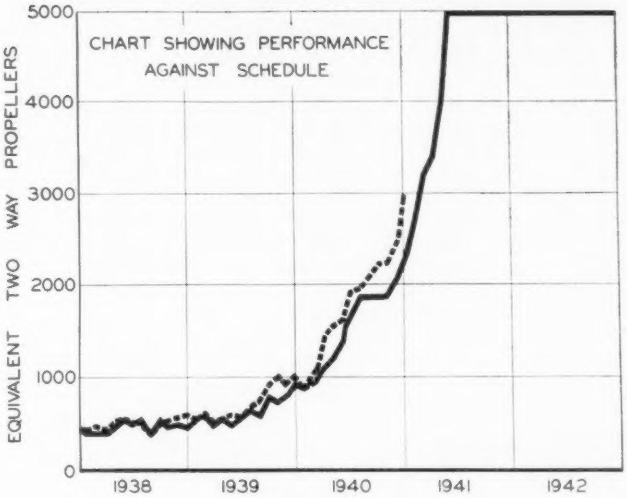

FIG. 8 PERFORMANCE AGAINST SCHEDULE

the number of supervisors that are going to be required, but also the dates when they will be needed. With this information it is possible to plan for and develop a supervisory staff in the manner already outlined.

Material is ordered and scheduled, like machines and men, from the original manufacturing schedule. Purchase orders are issued scheduling delivery of material, sufficiently before it will actually be required, to provide time for inspection. These schedule dates also include an advance which provides for a certain limited amount of flexibility for changing a small proportion of the schedule and provides a margin of safety for unforeseen delays of moderate size. The dates on the purchase orders, rather than material shortages, are the bases on which all follow-up work is conducted. The new method of inspection and materials control which was mentioned at the beginning of this paper so simplified our materials records that we were able to do all of our ordering for the national-defense program with the addition of only one clerk.

RESULTS OF METHOD

An indication of the soundness of the steps taken in our planning for accelerated production (see Fig. 7) are these figures from our last year's operation:

	1939	1940
Floor space	100	119
Salaried employees	100	145
Nonproductive labor	100	183
Productive labor	100	221
Equivalent "two-ways" produced	100	243

In Fig. 8, which shows performance against schedules, it is interesting to note that in a period covering three years the performance follows very closely the required schedule. This is not a thing that just happens, but it has been accomplished by coordinated planning among all departments, usually accompanied by a frank discussion of the problems involved and a complete and full acceptance, by the whole organization, of whatever decision was finally made. Also on the credit side of the ledger is the fact that, throughout this accelerated production, in spite of three shifts, six days a week, carrying bonus and overtime, there has been no increase in cost, but rather a decrease. Planning alone does not attain the objective. Personnel and morale of the best are, of course, prime essentials. We have had these available and it is our constant endeavor to maintain and improve these priceless assets. The results, to date, speak for themselves.

Application of COMPRESSION-IGNITION OIL ENGINES *to* AVIATION

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IN THIS country there has been a lack of development, or at least an exceedingly slow and inefficient development, in the field of compression-ignition aircraft engines. Beyond any doubt, this type of engine will become an important branch of the oil-engine industry and a useful machine in America's National-Defense Program.

It is incorrect to apply the name "Diesel engines" to compression-ignition mechanical-injection aircraft engines. Instead of using the typical Diesel cycle with a constant-pressure combustion, Fig. 1, indicator diagram *b*, these engines operate on a combination cycle, diagram *a*. Fig. 1 shows clearly the difference

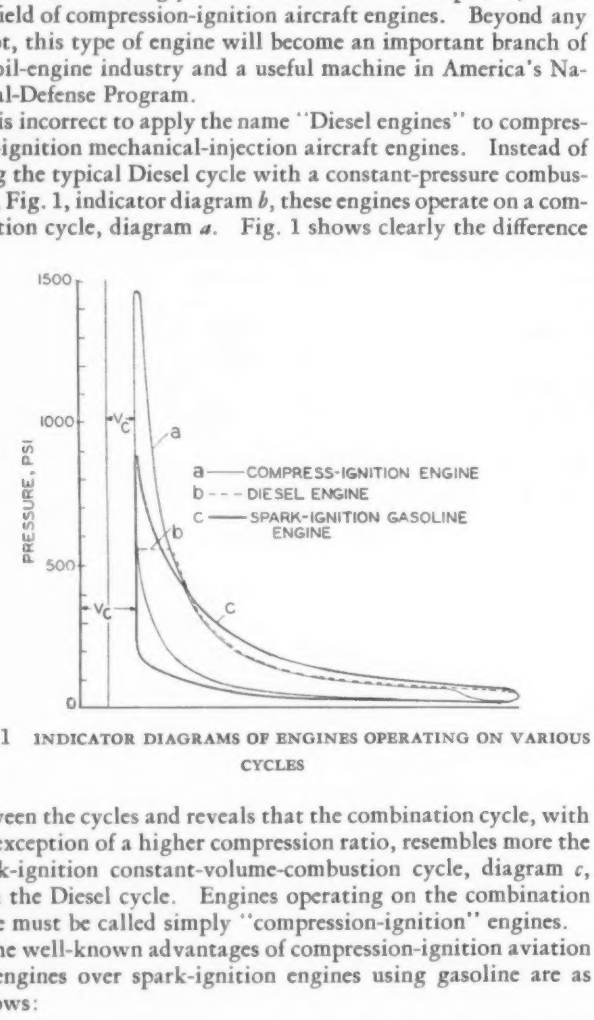

FIG. 1 INDICATOR DIAGRAMS OF ENGINES OPERATING ON VARIOUS CYCLES

between the cycles and reveals that the combination cycle, with the exception of a higher compression ratio, resembles more the spark-ignition constant-volume-combustion cycle, diagram *c*, than the Diesel cycle. Engines operating on the combination cycle must be called simply "compression-ignition" engines.

The well-known advantages of compression-ignition aviation oil engines over spark-ignition engines using gasoline are as follows:

(*a*) Greater safety, no danger of explosion of the fuel when a fuel-tank leak develops or of igniting it in the event of a crack-up.

(*b*) Lower fuel consumption, by about 20 per cent, which in turn gives:

(*c*) A greater flight distance without refueling for commercial airplanes, or a greater cruising radius for military planes.

(*d*) A greater pay load for the same fuel supply.

(*e*) A saving in the cost of fuel, particularly since the fuel oil costs only a fraction of the cost of aviation gasoline.

(*f*) Absence of radio interference.

(*g*) Absence of carbon monoxide in the exhaust gases.

All of these features are very valuable to commercial aviation while (*c*) and (*d*) are very important for military airplanes, and particularly for long-range bombers.

In view of these important advantages, it is strange that the only country which has actually developed and is building and using compression-ignition aviation engines is Germany. Steps toward development of these engines are being taken in Great Britain, France, and in the United States, but so far no practical results have been accomplished.

It is interesting to try to determine the causes of such a situation. Every more or less important development must overcome three types of difficulties: (*a*) of a technical or technological nature; (*b*) in respect to financing the development steps; and (*c*) active or passive psychological resistance of future users.

The technical difficulties or rather problems which must be solved before a practical engine can be built and the present status of their solution will be briefly stated.

DEVELOPMENT PROBLEMS TO BE SOLVED

Fuel Injection and Combustion. Due to the short time element available for injection and combustion in compression-ignition engines when they run at speeds of 2000 rpm and over, methods which give satisfactory results with existing medium-speed engines, such as truck or tractor engines, are not satisfactory.

On the other hand, the encountered difficulties are much smaller in an aviation engine in which the variations of speed and load are relatively small, than in a passenger-car or truck engine and can be met by the selection of a proper combustion chamber and a suitable injection system.

Basically, the problem of fuel injection, including its atomization and penetrating capacity, is solved. The injection systems of various manufacturers, who have specialized in this field, e.g., American Bosch, Ex-Cell-O, Timken, Bendix-Scintilla, Deco, present a variety of fuel-spray characteristics from which those most suitable for a high-speed engine with a given combustion chamber can be selected. While certain further improvements in the existing injection systems are desirable, the ways to these improvements are more or less established and the present methods of fuel-spray investigation by means of a stroboscope and special fuel-delivery analyzers permit a fairly accurate evaluation of the system even before it is tried in the engine.

Combustion Chambers. From the great number of combustion-chamber types used in compression-ignition engines in general, three types have given good results in aviation engines in actual

For presentation at the National Meeting of the Oil and Gas Power Division, Kansas City, Mo., June 11–14, 1941, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

performance or development research: (1) The open chamber for two-stroke-cycle engines (Junkers and N.A.C.A. test engine); (2) the displacer type (N.A.C.A. test engine); (3) the energy-cell chambers (Bayerische Motoren Werke-Lanova engine) for four-stroke-cycle engines. While the open chamber was tried in several four-stroke-cycle aviation engines, its main disadvantage is a comparatively low brake-mean-effective pressure (bmep). The only American compression-ignition aviation engine on the market, the four-stroke-cycle Guiberson A-1020 engine, has an open chamber and develops a bmep of 111 psi at rated horsepower, unsupercharged. Experimental work with the object of changing it over to the Lanova combustion chamber and equip it with a supercharger, both changes aiming at a higher bmep, is being conducted now.

Induction System. Exhausting the products of combustion and admitting the fresh charge, basically do not differ from these phenomena in spark-ignition engines. The experience with supercharging spark-ignition engines also can be applied in full to compression-ignition engines, including the desirability of a considerably greater overlap of the exhaust and intake periods than with natural aspiration.

Specific Weight (Pounds per Horsepower). The combustion pressure in a compression-ignition engine is higher than in a spark-ignition engine and this naturally requires slightly larger dimensions for certain parts, such as piston top, connecting-rod section, crankshaft diameter, which in turn increases the weight of the engine as a whole. Numerically the unavoidable increase is given sometimes[1] as proportional to the ratios of the maximum pressure over the mean effective pressure for the corresponding engine. Thus, in a spark-ignition engine with a compression ratio of 7.5:1 these pressures are about 880 psi and 135 psi, respectively, or a ratio of 6.5:1, whereas, in a compression-ignition engine having a compression ratio of 15:1, they are 1450 and 112 psi, or a ratio of 13:1; the ratio of weights is expected to be about 2:1. However, this figure is not correct; the weight of the compression-ignition engines need not be 100 per cent higher than that of the spark-ignition type. (1) The dimensions of parts are influenced not only by the maximum forces but also by the rate of rise of the pressures. In this respect, the compression-ignition engine is better off, the compression pressure being around 560 psi, the pressure rise is only $1450:560 = 2.6$ times, whereas, in a spark-ignition type, it is about $880:215 = 4.1$ times. (2) There are many parts in an engine, such as the crank-case castings, cooling fins of the cylinder, lubricating pumps, etc., whose dimensions are not influenced by the maximum pressure. Thus, the unavoidable increase in weight should not be over 50 and possibly only 35 per cent. These figures correspond quite closely to actual weight figures.[2]

Prof. W. Kamm of Stuttgart in 1938 prepared a report for the Bayerische Motorenwerke management, reviewing the development work in BMW-Lanova aviation engines and indicating in what directions the future design should go.[3] In this report he estimates that a compression-ignition aviation engine properly designed will weigh about 25 per cent more than the mean value of corresponding successful gasoline engines or 45 per cent more than the lightest existing gasoline engine. If one considers that the weight of spark-ignition aviation engines is now approximately 1 lb per hp, then the difference of 35 per cent becomes only 0.35 to 0.4 lb per hp, a difference which is absorbed due to the lower fuel consumption after only 3.5 to 5 hr of flight.

These figures are very close to those given by Münzinger for German compression-ignition aircraft engines, 1 lb per hp for a 700-hp engine, and 1.39 lb per hp for a 1000-hp engine.[4]

Mean Effective Pressure. Due to the nature of its cycle of operation, a compression-ignition engine must have more excess air than a spark-ignition engine. Therefore, the best bmep, which so far has been obtained by a four-stroke-cycle engine with natural aspiration, is about 117 psi.[5] By supercharging, the bmep can be materially increased, as shown in Fig. 2, representing test data taken from the report of Prof. W. Kamm.[3] The flatter shape of curve *a* is due to insufficient cooling of the test

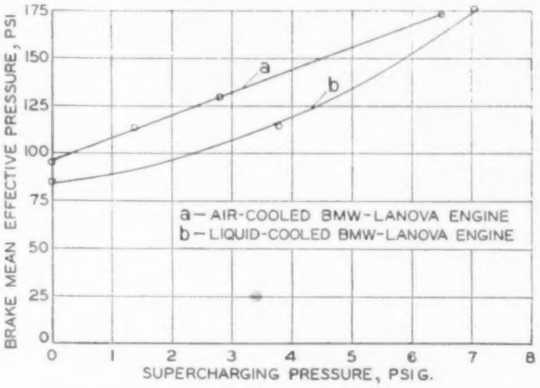

FIG. 2 INCREASE OF BRAKE-MEAN-EFFECTIVE PRESSURE BY SUPERCHARGING

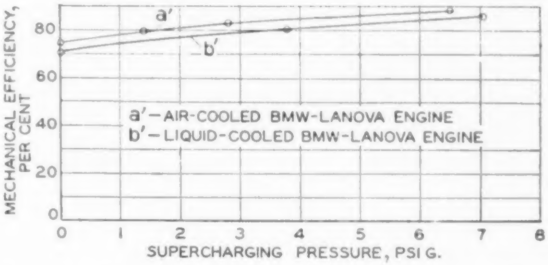

FIG. 3 INCREASE OF MECHANICAL EFFICIENCY BY SUPERCHARGING

engine at higher outputs. Curve *a* refers to a later and further developed engine than curve *b*, hence, the difference in values of the ordinates. Part of the gain in bmep through supercharging is due to an increase of the mechanical efficiency, as shown by curves *a'* and *b'*, Fig. 3, in the same way as mechanical efficiency increases with an increase of the load. However, an increase of the supercharging pressure is connected with an increase of power to drive the supercharger. Thus, these tests prove that the gain of power is considerably greater than the increase of the supercharger-drive load.

Dependability. The reliability of an aviation engine depends to a considerable extent upon its accessories. A great advantage of the compression-ignition aviation oil engine is the absence of the electrical-ignition system, with its magnetic spark plugs and shielded wiring, all of which are subject to breakdown.

The possibility of failure of a link in the fuel-injection system is considerably less than in the spark-ignition system and, besides, the failure of the injection system of one cylinder does not affect the operation of the other cylinders nor does any un-

[1] "High Speed Diesel Engines," by A. W. Judge, Second edition, D. Van Nostrand Company, Inc., New York, N. Y., 1935, p. 261.

[2] "Aircraft Diesels," by P. H. Wilkinson, Pitman Publishing Corporation, New York, N. Y., 1940, pp. 11, 91, 95, 109.

[3] A copy of this report was made available to the author through the courtesy of Hans Fischer, vice-president of the Lanova Corporation.

[4] "Entwicklungsrichtungen im Bau von Kraftmaschinen für Verkehrsmittel und ortsfeste Anlagen," by F. Münzinger, *Zeitschrift des Vereines deutscher Ingenieure*, vol. 82, 1938, p. 975.

[5] Reference 2, pp. 103, 115.

burned dangerous air-fuel mixture escape in the exhaust manifold.

The second advantage is in the nature of the fuel induction method. Carburetors require complicated boost and altitude controls to maintain a desired air-fuel ratio at all altitudes and all conditions, whereas, in a compression-ignition engine, the fuel control is rather simple. The engine is not sensitive to the air-fuel ratio and can operate with variable excess air without any trouble. Furthermore, there is no danger of ice formation in the air intakes of the oil engine as it exists in carburetor engines due to the temperature drop caused by the evaporation of gasoline.

The dependability of compression-ignition aviation engines is proved by almost 10 years of operation by the German Lufthansa on its commercial flights, which at the end of 1938 covered 4,250,000 miles, including many crossings of the North and South Atlantic Oceans.

Upkeep. While the pressures in a compression-ignition engine are somewhat higher than in a gasoline engine, the temperatures, both during the combustion and during the exhaust, are considerably lower than in a gasoline engine. This means less wear, more hours of operation between overhauls, and lower upkeep cost. These considerations are fully confirmed by the experience of the German Lufthansa.

This brief review shows that there are no insurmountable difficulties of a technical nature; in fact, the experience of German commercial and military aviation indicates that compression-ignition aircraft engines are superior to gasoline engines.

The absence of great technical difficulties is confirmed also by the fact that a comparatively small organization, without any previous experience in building internal-combustion engines and depending upon machine shops not accustomed to precision work, was able to produce the Guiberson A-1020 engine which has passed the rather rigorous Department of Commerce rating tests.

BUSINESS DEPRESSION PREVENTED DEVELOPMENT OF COMPRESSION-IGNITION ENGINES

Strange as it may seem, financial difficulties are to a great extent responsible for the fact that this country does not have compression-ignition aircraft engines. The Packard Aircraft Diesel engine was developed with a great expenditure of money and was abandoned during the 1932–1933 depression, in spite of the fact that the factory was already equipped for a mass production of the engine. Lack of orders prompted the decision not to invest more money under the circumstances.

The Aviation Diesel Engine Company of Los Angeles, Calif., developed a very promising radial air-cooled 400-hp engine with a considerable investment of money during the 1930–1934 years and failed because of lack of funds and of prospective orders.

The Deschamps 950–1200-hp 12-cylinder inverted V-type liquid-cooled engine was started in 1939 by the Lambert Engine Company, Moline, Ill. However, before the development was completed and the engine was tested in flight, the death of the main financial backer stopped further work on this engine.

In addition to these widely known failures, the author has knowledge of several smaller development efforts which all failed primarily due to lack of a sufficient financial backing when the original capital was exhausted and no new money was coming in. Some of these developments seemed to have considerable merit from an engineering point of view.

PSYCHOLOGICAL DIFFICULTIES

Very peculiarly, the aviation industry of this country does not seem to be interested in compression-ignition engines, in spite of their advantages which are known to all technical leaders. They did not encourage the efforts of pioneers in this field. Companies building gasoline aircraft engines also do not seem to be interested in the development of the compression-ignition engine. Their attitude can be understood, but not approved; evidently they have more orders on hand for gasoline engines than they can deliver, and the diversion of attention to a new type does not appeal to them at this time. However, this is a shortsighted policy. The situation is similar to that in the automotive industry, i.e., while for passenger cars the gasoline engine due to its flexibility may continue to be used at least for several years to come, in long-haul trucks, in tractors, excavators and road-building machinery, in all fields where fuel economy, is essential, compression-ignition oil engines gradually and steadily are taking the place of gasoline engines. The compression-ignition engine has such important advantages for airplane propulsion that, in the near future, it will dominate the field, particularly for large commercial and powerful military planes.

On the other hand, builders of high-speed compression-ignition engines for other purposes, such as the General Motors Corporation with its successful two-stroke-cycle engines, seemingly are not interested in the development of an aircraft engine.

There remains only one more organization which should be interested in compression-ignition aircraft engines, the N.A.C.A. Indeed, the N.A.C.A. long ago recognized the coming importance of compression-ignition aircraft engines. Extensive research work is being done covering many phases of engine design, fuel injection, shape of combustion chambers, type of intake and exhaust valves, their timing, supercharging of engines, etc. Experimental single-cylinder engines have been built which showed exceptional features, particularly in respect to bmep. Unfortunately, the work done in the Langley Field Laboratory seems to have become detached from practical application, to present a more purely scientific research than preliminary work to an industrial development.

The results of these investigations together with a few translations of important foreign papers, published by the N.A.C.A., form a small library in itself, covering all the more important questions connected with the development of compression-ignition oil engines.[6]

The N.A.C.A. is building a new large laboratory at Cleveland, Ohio, exclusively for aircraft-engine research. Let us hope that this laboratory will carry out not only research but actual development of compression-ignition aircraft engines.

As a final indication of an inexplicable lack of interest in compression-ignition aircraft engines may be mentioned the fact that, in a comprehensive review of the latest progress in aeronautical engineering, aircraft engines are discussed in two places,[7] but compression-ignition engines are not even mentioned.

FUTURE AIRCRAFT ENGINES

Using data obtained from German engines actually in use, the American Guiberson A-1020 engine, Prof. W. Kamm's report,[3] P. H. Wilkinson's book,[8] and mechanical-engineering considerations, based on experience with the design of high-speed compression-ignition engines and of aircraft engines in general, the author takes the liberty of outlining the starting points of development of compression-ignition aircraft engines.

The following preliminary questions must be decided before

[6] These publications can be divided into six groups: Diesel Fuels and Their Behavior in Compression-Ignition Engines, 11 publications; Combustion in C-I Engines, 13; Injection Systems and Injection Phenomena, 35; Experimental Investigation of Different Valve Systems and Combustion Chambers, 12, Two-Stroke-Cycle Engines, 7; Miscellaneous, 5.

[7] "Technical Progress in Aviation," by J. C. Hunsaker, MECHANICAL ENGINEERING, February, 1941, p. 97; and "Development in Aircraft Power Plants," by A. T. Gregory, ibid., p. 103.

[8] Reference 2, p. 255.

TABLE 1 DESIGN FEATURES OF COMPRESSION-IGNITION AIRCRAFT ENGINES FOR VARIOUS POWER REQUIREMENTS

Group	1	2	3	4	5
Range of power, bhp	60 to 160	160 to 400	400 to 900	900 to 2000	2000 to 3200
Cycle of operation, strokes	4	4	4 or 2	4 or 2	2
Cylinder arrangement	In-line or radial	In-line or radial	In-line banks or radial	In-line banks or radial	In-line banks
Cylinder number	4 to 7	6 to 14	6 to 18	9 to 24	16 to 24
Cooling by	Air	Air	Air or liquid	Air or liquid	Liquid
Supercharger (drive)	None	None or geared	Geared or exhaust	Exhaust driven	Exhaust driven
Combustion chamber	Open or energy cell	Open or energy cell	Open or energy cell	Open	Open
Speed, rpm	2200 to 2500	2100 to 2400	2000 to 2300	1900 to 2200	1800 to 2100
Bmep, psi	110	120 to 135	138	142	145
Fuel consumption, lb per hp-hr	0.39	0.38	0.375	0.37	0.365
Engine weight, lb per hp	2	1.8	1.6	1.4	1.3

aircraft-engine design is started: (*a*) Cycle of operation, two or four stroke; (*b*) cylinder arrangement and their number; (*c*) type of supercharger; (*d*) type of combustion chamber; (*e*) intake and exhaust systems; (*f*) method of cooling; (*g*) rotative speed and connection to propeller.

In addition, the following three characteristics may be assumed from existing data and used as desirable and possible goals to be attained: (1) Expected brake-mean-effective pressure, pounds per square inch; (2) fuel consumption, pound per horsepower-hour; and (3) engine weight, pounds per horsepower.

Naturally engines of different horsepowers will differ by their type, construction, and details.

FEATURES OF ENGINES IN VARIOUS POWER GROUPS

Table 1 gives the probable design features of engines in five more or less distinctive power groups, corresponding to the various airplane types, from sport planes to transoceanic airliners and heavy bombing planes.

A brief explanation for the selection of the more important corresponding features follows:

Cycle of Operation. The four-stroke-cycle type has certain advantages, such as a simpler scheme of operation. Backed by the experience accumulated from gasoline aircraft and automobile engines, probably this type will be used in the small- and medium-power classes. The two-stroke-cycle type is bound to be used in the larger engines, columns 4 and 5, Table 1, in a manner similar to the applications in marine and railroad practice. The important advantages of the Junkers engine from the standpoint of fuel economy, mean effective pressure, and intrinsic balance of reciprocating masses are to a certain extent offset by the construction difficulties of interconnecting the two pistons in each cylinder. In this respect there seem to be interesting possibilities in the construction recently brought out by Sulzer Bros., Switzerland,[9] Fig. 4. In this design, both pistons act upon the crank of the same shaft by means of rocker arms and connecting rods. The scheme lends itself best for horizontal engines. A pair of such engines can be located inside the wings. The mechanism of Fig. 4 has another advantage: If the crankshaft is set slightly below or above the line connecting the lower ends of the rocker arms, the travel of one of the pistons near the dead center is retarded in respect to that of the other. With the arrangement of Fig. 5, the exhaust ports are uncovered by the left-hand piston before the scavenge ports are uncovered by the right-hand piston and thus the necessary pressure release of the exhaust gases is effected. On the return stroke, the exhaust ports are closed in advance of the scavenge ports, thus giving a certain degree of supercharging. The time element of the advance depends upon the angle α. The intrinsic balance of the reciprocating masses is also better than in the Junkers scheme with one crank advanced with respect to the other.

Cylinder Arrangement. The radial arrangement of cylinders is favored in this country and is being used up to 2000 hp. In this power range, the 14-cylinder double-row engine offers a more favorable solution from the viewpoint of design, assembly, and servicing, than the 18-cylinder double-row engine. However, the latter has the advantage of being about 8 per cent lighter. For engines of over 1200 hp the cylinders arranged in line in two or four banks have the advantage of a smaller drag than the radial arrangement.

Cooling. Up to 120–135 hp per cylinder air cooling can be used satisfactorily. Higher output per cylinder probably will require liquid cooling. On the other hand, liquid cooling has decided advantages even for smaller engines, particularly in respect to reducing the wear of pistons and piston rings. However, the question of cooling may be considered of minor importance as both types have their strong and weak points.[10]

Combustion Chambers. While the existing four-stroke-cycle engines have open combustion chambers, extensive tests with the energy-cell type, conducted by the Bayerische Motoren Werke in Germany and by the Lanova Corporation in this country, indicate that the energy cell permits increase of the bmep to about 140–152 psi and, at the same time, gives a reasonable fuel consumption of about 0.4 lb per hp-hr.

The two-stroke-cycle engines, both of the General Motors uniflow type and of the Junkers opposed-piston type, due to the

[9] Sulzer Technical Review, no. 3, 1940, p. 1.

[10] Hunsaker, reference 7, p. 96.

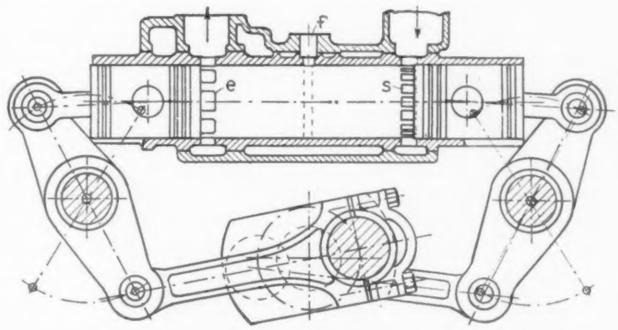

FIG. 4 TWO-STROKE OPPOSED-PISTON TYPE SULZER ENGINE, REQUIRING ONLY ONE CRANKSHAFT

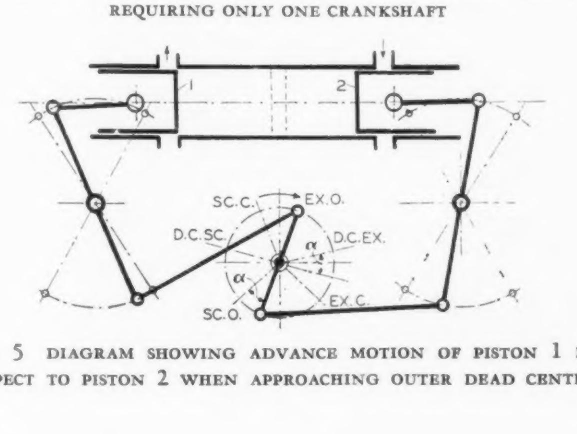

FIG. 5 DIAGRAM SHOWING ADVANCE MOTION OF PISTON 1 IN RESPECT TO PISTON 2 WHEN APPROACHING OUTER DEAD CENTER

turbulence created by the tangential air-inlet ports, utilize open chambers. Tests conducted by the N.A.C.A. Laboratory with a combustion chamber having a displacer piston gave good results.[11] However, this chamber is rather sensitive to clearance proportions. A similar arrangement, after being used for several years in the stationary engines by Otto-Deutz Engine Works, finally was abandoned.

Intake and Exhaust Systems. Again, in spite of the favorable results obtained by the N.A.C.A. Laboratory with special rotary and sleeve valves, practical experience indicates that poppet valves made of suitable steel and operated by properly designed cams give the safest, most dependable performance. It may be well to remember the Knight sleeve-valve engines. Some 20 years ago, they were considered the best and most silent engines and many high- and medium-priced automobiles were equipped with them. However, the metallurgical improvements in valve and seat materials gradually restored the poppet-valve engines as the only type used in American cars and practically the same has happened in Europe.

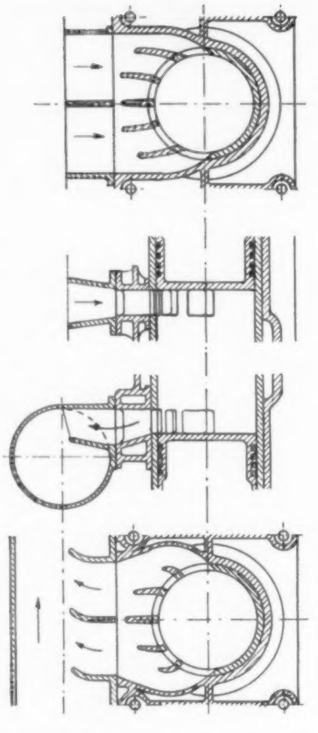

FIG. 6 EXHAUST AND SCAVENGE PORTS WITH GUIDE VANES

Ports, controlled by piston edges, as used in two-stroke-cycle engines, have so many advantages that they undoubtedly will be used whenever the general construction permits it. The performance of engines with ports can be materially improved by using guide vanes,[12] as shown diagrammatically in Fig. 6, for an opposed-piston engine.

Rotative Speed. The suggested speeds are those which have given satisfactory performance in existing and experimental engines. Based on automobile-engine practice, one can expect that the engine speeds can be considerably increased, which will reduce the specific weight in pounds per horsepower, but will require a reduction gear between the engine and the propeller.

Mean Effective Pressures. The pressures to be sought are those already obtained in various aircraft compression-ignition engines, either in actual performance or on the test stand with experimental engines. However, the figures given in Table 1 are conservative, much higher figures being obtained in many experimental tests. Thus, N.A.C.A. test engines showed bmep of 158 psi for air-cooled and 200 psi for water-cooled engines.[13]

Fuel Consumption. All statements in the preceding paragraph in respect to bmep can be repeated here. In fact, fuel-consumption figures as low as 0.34 to 0.35 lb per hp-hr have already been obtained and naturally will be obtained again when the engines are built, properly developed, and tuned up.[14]

Weight of Engines. The weight figures in Table 1 again are conservative, 1.43 lb per hp being actually obtained for a 700-hp Jumo 207 engine[14] and as low as 1.17 lb per hp for a Jumo 224 engine.[15]

CONCLUSION

While the object of Table 1 is to show that the work done so far by various engine builders and experimental organizations has furnished enough data to make possible the building of compression-ignition aircraft engines, much development work has yet to be done. However, the only way of developing a new aircraft engine is to build it, test it on the ground, and then put it in an airplane and test it in flight. Only testing in actual flight can result in a usable engine. Only flight tests showed that the Packard engine was not yet suitable for actual use, although ultimately it could have been developed into a usable engine. The untimely death of its designer during a test flight and the discontinuance of further test flights are responsible for the disappearance of this promising engine from the market.

In the United States, so far the most progressive country in all industrial and technical fields, the best and most powerful gasoline aircraft engines are built. Is it possible that the leaders in our aircraft industry and defense program will continue to overlook the importance of the compression-ignition aircraft engine and further postpone its development?

[11] "Performance Tests of a Single-Cylinder Compression-Ignition Engine With a Displacer Piston," by C. S. Moore and H. H. Foster, U. S. National Advisory Committee for Aeronautics, *Technical Note*, No. 518, February, 1935.

[12] "Strömunsfragen am Dieselmotor," by E. Sörensen, *Zeitschrift des Vereines deutscher Ingenieure*, vol. 84, 1940, p. 884.

[13] Reference 2, p. 221.

[14] Reference 2, pp. 99, 107, 109, 227.

[15] Reference 2, p. 227.

Wisp of Wire Controls Steel Quality

A strange chemical tug of war goes on when a piece of steel is heat-treated in an atmosphere of protective gas. Normally the gas contains some carbon, which it tries to inject into the steel. But the hot steel may have no appetite for carbon, so it generously shares its store of that element with the gas.

J. R. Gier of the Westinghouse Electric & Manufacturing Company recently built an instrument—ingenious because it is simple—that allows scientific control of the carburization process. A fine iron wire is suspended in an airtight glass tube and heated by an electric current to about 1800 F in a stream of the carburizing gas.

In practice, while the wire is heated, the gas is varied until the resistance of the wire corresponds to the desired carbon content of the steel; then no further change in gas is necessary.

Precision comes from a peculiar electrical characteristic of steel. Normal carbon content varies from zero to about $2^1/_4$ per cent in commercial steels, but this slight chemical variation produces a change of more than 300 per cent in electrical resistivity of the metal.

As a check on the accuracy of his method, Mr. Gier heat-treated two pieces of steel—one carbon-free, the other with a known carbon content—in a gas of unknown carburizing potential. From calibration curves of the hot-wire instrument he computed the percentage of carbon in the treated steel. Precise chemical analysis verified the computation within 0.01 per cent.

The hot-filament instrument will be particularly valuable in these days of high-speed metal fabrication. Its original use was for control of atmospheres for steel-hardening furnaces, but it can be used also for controlling special atmospheres, as in sintering metal powders.

Operation of STEAM *Vs.* DIESEL-ELECTRIC LOCOMOTIVES

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FOR a period of something over a hundred years, the steam locomotive has been developing on the American railroads, and up until about 1900 the progress was in producing more power by means of more weight on drivers, increased size of boilers and cylinders, boiler pressures raised from 50 to a maximum of about 225 psi, and improvement in valve motion. During this period the length of locomotive runs was generally from 100 to 150 miles.

From 1900 to date, compound locomotives, both of rigid and articulated type, were tried out thoroughly and discarded, mainly because of increased repair costs. The Schmidt, Emerson, Baldwin, and Jacobs superheaters were investigated and the Schmidt retained. Feedwater heaters or exhaust-steam injectors were developed and one or the other are now standard on most railroads.

High-pressure boilers with pressures up to 1100 psi utilizing tubular-type fireboxes were placed in service. However, to date the maximum pressure for conventional stayed-type fireboxes has settled at about 310 psi. There are some water-tube fireboxes in service. Single-expansion articulated locomotives are still used for heavy-duty freight service, and repeat orders indicate that careful study has justified the continued use of such types of steam locomotives.

In the last ten or twelve years, the application of roller bearings to journals of passenger locomotives has gradually increased, and at present this type of bearing is entering the freight-locomotive field. Roller bearings have also come into use in valve-motion parts, and in main-rod and connecting-rod bearings. The benefit of such bearings is apparent on long locomotive runs with few stops, in that their use eliminates the need for servicing such parts en route.

The need for sustained power output at higher sustained speeds introduced a demand for high steam rates some 25 years ago which resulted in the development of the coal stoker. The development of the stoker in conjunction with increased boiler and firebox heating surface has increased steam-generating capacity of coal-burning locomotives to 80,000 to 100,000 lb of steam per hour. This higher boiler output has also been accomplished by the adaptation of oil-refinery residuum as a locomotive fuel in sections of the country where this type of fuel oil is readily available.

The demand for higher sustained speed has brought about the use of tenders of 25,000 gal water capacity where water is not taken from track pans with the train in motion. The New York Central Railroad, which takes water with train in motion from track pans by water scoop, has reversed this general practice of increased water capacity tenders on American railroads. On this railroad the water capacity of tenders has been reduced and coal capacity increased to 43 tons from a previous maximum of 28 tons. This allows longer locomotive runs between refueling points and elimination of time lost by stopping and starting as well as time required to take fuel.

From time to time poppet valves have been applied to locomotives. A recent development of such a valve and the necessary operating mechanism has given a successful demonstration in both road and test-plant performance. The improved steam distribution is marked by an increase in power output with a decrease in steam consumption.

The merits of this device are in independent control of intake and exhaust events, reduction in friction, and consequently in power required to move the valve gear. A further advantage is that by proper mechanism such valves can be used as by-pass valves through holding open steam-intake and closing exhaust valves which prevent smokebox gases from entering the cylinders. This saves fuel and keeps the cylinders in properly lubricated condition. The possibilities of control of individual valve events offer economies in steam consumption, increase the power output particularly at higher speed with the same boiler capacity, and offer possibilities of reduced maintenance costs of valve gear.

ELECTRIC AND DIESEL-ELECTRIC LOCOMOTIVES BEGIN TO COMPETE WITH STEAM

With all the improvements in steam motive power, increasing demand for more horsepower and higher speeds provided the opportunity for the introduction of other types of motive power.

About three decades ago when the electric locomotive, which secures its power from outside sources, was developed, designers prophesied that within the next decade the railroads of the United States would purchase only electric locomotives for new power. While this prophecy has not been fulfilled, certain railroads in this country have electrified their motive power on selected parts of their roads. There are about 900 such electric locomotives in service at the present time. The heavy expenditures required for stationary power plants and power lines have limited such applications generally to heavy-traffic lines, or to locations where electric power was available from hydroelectric plants, or where power plants could be located at mine head to avoid expense of handling fuel.

Previous to this period an internal-combustion engine was invented by Rudolph Diesel which utilized the heat of compression for igniting the fuel. This engine showed a high thermal efficiency, and such engines were installed widely in stationary and in marine service. However, the weights of these engines were so excessive there was no extensive use of them in the railroad propulsion field before 1925. From 1925 to 1935 a steadily increasing number of such engines with electrical transmission was placed in switch service. In 1935 a two-cycle Diesel engine of considerably less weight per horsepower was developed by the Winton Company, which was later taken over by the Electro-Motive Corporation. Since then both two-cycle and four-cycle Diesel engines have been used extensively in switch locomotives. Most of the applications to passenger and freight locomotives to date have been two-cycle engines, but some four-cycle Diesel engines are now in passenger service.

Contributed by the Railroad Division for presentation at the Semi-Annual Meeting, Kansas City, Mo., June 16–19, 1941, of The American Society of Mechanical Engineers.

Since 1925, a total of about 1300 switch, passenger, and freight Diesel-electric locomotives have been placed in service, of which approximately 35 per cent went into operation in 1940.

In this comparison of various prime movers on American railroads it is well to show the trend of purchases of the three principal types of locomotives for the last five years as given in Table 1.

TABLE 1 LOCOMOTIVES ON DOMESTIC ORDER, 1936–1940
(*Railway Age*, Jan. 4, 1941)

Year	Steam	Diesel-electric	Electric
1936	435	77	24
1937	173	145	36
1938	36	160	29
1939	95	246	32
1940	219	462	13
Total	958	1090	134

For the year 1940 about 80 per cent of Diesel locomotives purchased were switchers and transfer locomotives, while 20 per cent were freight and passenger. On a horsepower basis, about 60 per cent were switchers and transfer, and 40 per cent freight and passenger Diesel locomotives.

For the year 1940 only six steam locomotives, or less than three per cent of whole, were purchased for switching service. The remainder were purchased for passenger and freight service. A careful analysis of switching operation indicates that where locomotives can be utilized for two 8-hr tricks per day or more, Diesel switch locomotives of 600 hp capacity (and above) are justified. Where Diesel switch locomotives with 44 tons of weight on driving wheels can be used they can be justified for one-trick-per-day service.

COMPARISON OF DIESEL-ELECTRIC AND STEAM LOCOMOTIVES

For comparative purposes the general dimensions and power performance characteristics of certain Diesel locomotives and comparable conventional steam locomotives are listed in Table 2. Power performance data, i.e., drawbar horsepower on level tangent track, are shown graphically in Fig. 1.

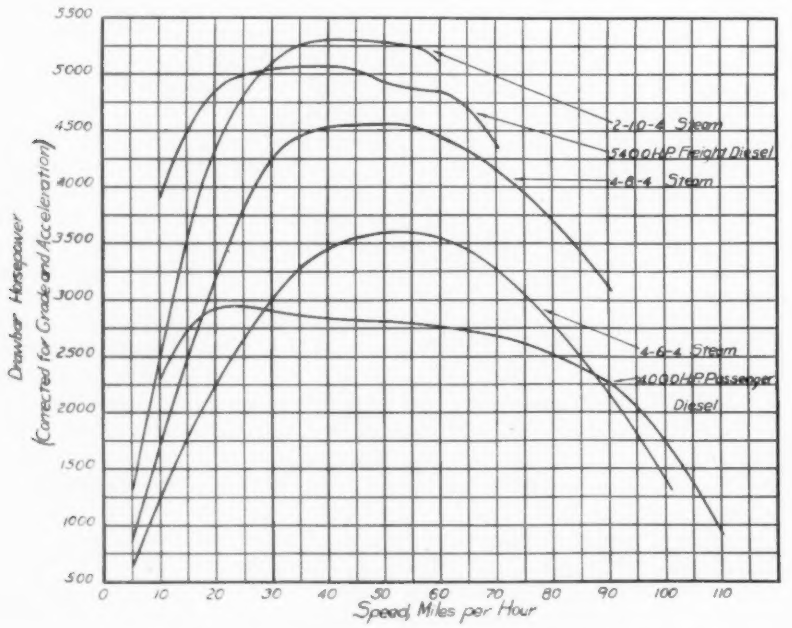

FIG. 1 POWER PERFORMANCE OF DIESEL AND STEAM LOCOMOTIVES
(Available drawbar horsepower on level tangent track, 4000- and 5400-hp Diesel locomotives and 4-6-4, 4-8-4, and 2-10-4 steam locomotives.)

TABLE 2 PRINCIPAL DIMENSIONS AND CHARACTERISTICS—DIESEL VS. STEAM LOCOMOTIVES

	Diesel locomotive		Steam locomotive		
	4000 hp	5400 hp	4-6-4	4-8-4	2-10-4
Length, over-all, ft-in.	141-7 1/2	193-0	102-6 3/4	112-1 1/4	113-6 5/16
Total wheel base, ft-in.	117-1	177-0	88-8	98-2 1/2	100-3 3/4
Rigid wheel base, ft-in.	14-1	9-0	14-6	13-10	19-3
Weight, total, lb.	626,200	923,600	808,626	895,846	934,766
Weight on drivers, lb.	426,800	923,600	213,440	286,890	371,990
Wheels, number and diameter, in.:					
Engine truck	8-36	.....	4-37	4-37	4-37
Drivers	16-36	32-40	6-84	8-80	10-74
Trailer truck	....	.....	4-40	4-40	4-40
Tender	....	.....	12-37	12-37	12-37
Fuel-oil capacity, gal	2400	4800	7000	7000	7000
Boiler - water capacity, gal.	2900	.....	21,000	21,000	21,000
Cooling - water capacity, gal.	600	900	....	....	....
Lubricating - oil capacity, gal.	520	700	....	....	....
Starting tractive effort, lb.	106,700	220,000	49,300	66,000	93,000
Factor of adhesion	4.00	4.20	4.33	4.35	4.00
Drawbar horsepower at					
10 mph	2270	3870	1210	1670	2430
20 mph	2930	4850	2240	3170	4340
30 mph	2910	5040	2990	4230	5100
40 mph	2840	5070	3450	4530	5310
50 mph	2810	4930	3600	4550	5280
60 mph	2760	4720	3550	4450	5120
70 mph	2680	4400	3270	4160	....
80 mph	2510	.....	2790	3720	....
90 mph	2260	.....	2160	3120	....
100 mph	1750	.....	1400	....	....
110 mph	950	.....	....	....	....

The 4000-hp Diesel and the 4-6-4 type steam locomotive are essentially similar. However, it can be seen that at speeds below 29 mph and above 87 mph, the 4000-hp Diesel locomotive has more horsepower available at the drawbar than the 4-6-4 type steam locomotive. The lesser weight of the 4000-hp Diesel locomotive is a distinct advantage also.

The 5400-hp Diesel locomotive is superior to the 4-8-4 type steam locomotive throughout its speed range. However, the 4-8-4 type steam locomotive is designed for a maximum speed of 90 mph, while the 5400-hp Diesel locomotive is designed for freight service primarily with speed limited by motor restrictions and gear ratio to a maximum speed of 77 mph. The 2-10-4 type steam locomotive develops more horsepower at the drawbar than the 5400-hp Diesel locomotive at speeds above 29 mph. However, the marked superiority in drawbar horsepower of the Diesel locomotive at speeds under 29 mph gives it a distinct advantage not only in starting and accelerating heavy trains, but also in maintaining higher speeds on ruling grades.

It should be noted, however, that motor limitations restrict the loading of the Diesel freight locomotive on any grade to what it will handle at a minimum speed of 16 mph and for Diesel passenger locomotive what it will handle at 35 mph at which respective speeds motors can be operated at continuous rated output.

ADVANTAGES AND DISADVANTAGES

Briefly the advantages claimed for Diesel locomotives over the conventional steam locomotives are as follows:

High thermal efficiency
Lower water costs
High utilization—greater flexibility
Reduction of delay due to taking fuel and water
Higher sustained speeds
Lower stresses imparted to track structure
Dynamic braking.

The disadvantages are as follows:

High initial investment
Lower life expectancy
Demand for higher degree of maintenance
Higher unit cost of fuel
Higher cost of lubrication.

Thermal Efficiency. A comparison of over-all thermal efficiency—ratio of power output at drawbar to heat content in fuel—shows the Diesel locomotive to have an average thermal efficiency of 26 to 28 per cent, while comparable modern steam locomotives have a corresponding thermal efficiency of 6 to 8 per cent. Because of this, there is a twofold advantage for the Diesel locomotive in that there is a reduction in the amount of fuel necessary to carry and an increase in the length of operation between refueling.

Lower Water Costs. On steam locomotives lower water cost is an item of some importance. The average water cost for a steam locomotive is approximately ten per cent of the fuel cost. On Diesel locomotives, water is a relatively small item even on passenger Diesels where steam generators are used to furnish steam for heating or for air-conditioning passenger trains. The amount of water required for this purpose is only about one tenth of the total water used for all purposes by a steam locomotive in the same service, so that for passenger Diesel locomotives water costs will be not over one tenth that for steam locomotives. For freight Diesel locomotives water costs are practically negligible.

Utilization and Flexibility. Utilization may be measured in two ways. For passenger and freight locomotives, the mileage per locomotive per year indicates directly the relative utilization. For passenger Diesel locomotives, the average mileage per year is 250,000 with a maximum monthly mileage of 27,000, as compared with 180,000 miles per year and a high monthly mileage of 18,000 to 19,000 for modern steam passenger locomotives. At the present time Diesel passenger locomotives are largely assigned to definite runs, for which their availability has proved to be 95 to 99 per cent. In switch service, utilization is usually measured by hours of service performed out of total monthly hours. In this service generally Diesel switch locomotives have a very high utilization factor.

The Diesel locomotive has a greater flexibility in that the locomotive may be accommodated to the train to be handled. On long runs over varying grades, one or more engines may be cut out entirely on lighter grades, where not necessary, and cut in for work in mountainous territory. This flexibility also permits of some inspection and light maintenance of engines while en route to keep them in first-class condition at all times. Where locomotives are in multiple units it is possible to use the minimum number of units required on level territory and add necessary units for work on heavy ascending grades.

Reduction in Delays. The reduction in delay time due to taking fuel and water is a distinct advantage for the Diesel locomotive. The ability of the Diesel locomotive to run long distances between fuel and water stations as compared with steam locomotives is an important consideration in long transcontinental passenger runs and also in the operation of expedited schedule freight trains. Delays between major terminals for fuel and water have been eliminated, and the terminals at which fuel and water are taken are so located that the delays for this service are at least partially absorbed in that some time is necessary at these terminals for other services.

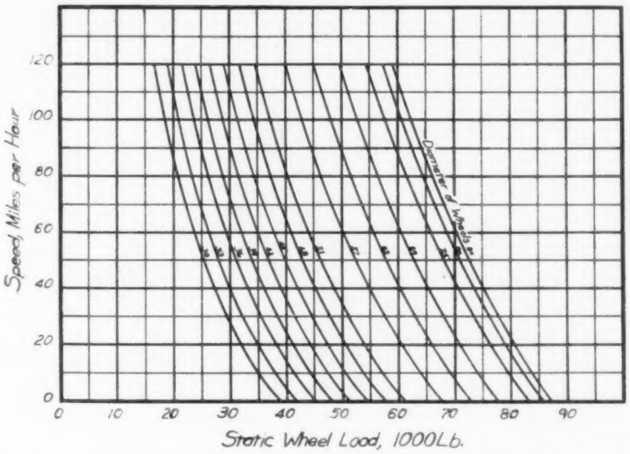

FIG. 2 ALLOWABLE LOAD ON RAIL FOR VARIOUS-DIAMETER WHEELS AND SPEED AT WHICH MAXIMUM SHEAR STRESS OF 25,000 PSI IN POTENTIAL SHATTER CRACK ZONE OF RAILS WILL OCCUR—WHEELS WITH NO UNBALANCED FORCES

Higher Sustained Speed. The reduction in delay time in stopping and starting for taking fuel and water permits of higher sustained speed, without the necessity for running at high maximum speeds. In addition, the high available drawbar horsepower in the lower speed range gives the Diesel locomotive an advantage in that considerably less time is consumed in accelerating to the speed required to make schedule time. Faster schedules are thus maintained at a more nearly uniform average speed and a lower maximum speed. The rapid acceleration of the Diesel locomotive at low speeds is a distinct advantage in freight service in that less time is required to accelerate to speeds of 16 mph or above where the continuous rating of the locomotive is utilized.

Lower Stresses in Track Structure. The stresses imparted to track by prime movers is an increasing concern to the management of railways. Diesel locomotives, which have no unbalanced weights in their wheels, remove the danger of kinking rails. However, with such locomotives able to travel at speeds up to 120 mph in passenger service, it is well to be sure that wheel diameters and wheel loads be so proportioned that shearing stresses in the head of the rail, and particularly in the potential shatter crack zone, be kept within prescribed limits.

Such limits are derived by mathematical computation of Hoersch and Thomas in Bulletin 212 of the University of Illinois, and in computation of shear stress by the Rail Committee of the American Railway Engineering Association, published in volume 42 of the Annual Proceedings of that society. The limits used are 67,000 psi maximum shear stress $^1/_8$ in. below the surface of the rail, and by keeping to this limit the shear stress in the zone of the rail where shatter cracks occur will be limited to a maximum of 25,000 psi. Test results have shown that a maximum shear stress of 25,000 psi in the potential shatter-crack zone will protect against propagation of transverse fissures from shatter cracks.

Fig. 2 shows the permissible static weight on rail and speeds at which limiting shear stress is reached for wheels having no unbalanced forces. The static weight is shown for zero speed

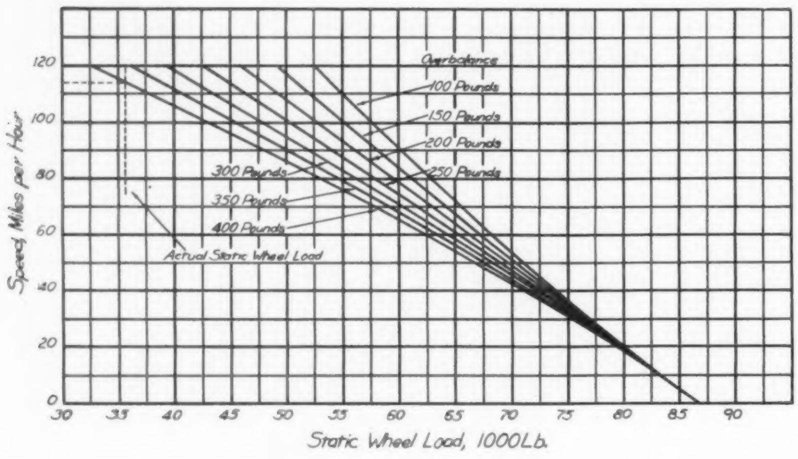

FIG. 3 MAXIMUM STATIC WHEEL LOAD ON DRIVING WHEELS AT VARIOUS SPEEDS FOR LIMIT SHEAR STRESS OF 25,000 PSI IN POTENTIAL SHATTER CRACK ZONE OF RAILS

(4-6-4 Type locomotive, $23^1/_2 \times 29^1/_2$-in. cylinders, 84-in. drivers, actual static wheel load 35,600 lb, variations in overbalance as indicated.)

as derived by the method already given. For any speeds the limiting static wheel load is computed by an empirical formula developed by G. M. Magee, research engineer of the American Railway Engineering Association, from data on stresses in railway track published by that association. This formula is based on speed effects due to track and wheel irregularities and is as follows:

$$\text{Speed effect} = \frac{(0.33S)W}{D}$$

in which S = speed, mph
D = diameter of wheel, in.
W = static wheel load, lb

The foregoing formula may give computed impact loads that are higher than actual, particularly with smaller wheels without unbalanced forces. While this penalizes the locomotive unduly, it has the virtue of affording a greater margin of safety against damage to either rail or wheel.

Analysis of the graph shows that with wheels of original diameter of 36 in. the maximum static wheel load should be 23,500 lb with locomotive confined to a top speed of 100 mph, or 21,500 lb with a top speed of 120 mph. When 36-in-diam wheels are worn to the limit they are only $32^1/_4$ in. in diameter, and for this diameter, maximum static wheel loads to hold shear stresses within prescribed limits should be about 20,000 lb for a top speed of 100 mph, and about 18,500 lb for a top speed of 120 mph. This would indicate that passenger Diesel locomotives with 27,000-lb wheel loads on 36-in-diam wheels may set up shear stresses beyond the prescribed limit when operating at the higher speed range. There is very little variation in wheel loads on Diesel locomotives, about the same weight being carried at all times. In order to protect against potential rail damage it is advisable to use larger wheels, which would be an advantage to both wheels and rails. On freight Diesel locomotives that have just gone into service, with top speeds of 77 mph, wheel diameters are nominally 40 in. and wheel loads 29,000 lb. This is just within the limit set for maximum shear stress, but allows no margin for possible additional weight owing to weight-adding improvements that may be justified.

The same condition exists with steam locomotives under wheels that have no unbalanced forces. However, on late designs of steam locomotives, front engine-truck wheels carrying a 23,000-lb load have been increased to 42 in. diameter, which would permit a static wheel load of 29,000 lb for a maximum speed of 100 mph. Similarly, trailer truck wheels carrying 29,000 to 30,000 lb are of 50 in. diameter, which permits of maximum static wheel load of about 35,000 lb at a speed of 100 mph.

On locomotive tenders, eight-wheel trucks have been used and 42-in-diam wheels are contemplated with wheel loads of 29,000 lb, tender fully loaded and 12,500 lb empty. It is only for a short period of time that full load of fuel and water is in the tender so that the loaded weight given should not develop shear stresses in wheels and rails in excess of the prescribed limit at higher speeds.

Under steam-locomotive driving wheels, dynamic augment due to overbalance in wheels adds another complication to the problem of stresses in track.

Fig. 3 shows the maximum permissible static load with overbalance at various weights and for different speeds from zero to 120 mph for a 4-6-4 type steam locomotive having 84-in. drivers, cylinders $23^1/_2 \times 29^1/_2$ in., and an actual static weight on drivers of 35,600 lb. It is apparent that for a maximum speed of 100 mph there is a margin of safety of about 25 per cent with the heaviest overbalance 400 lb. At 120 mph there is some margin of safety for overbalances not in excess of 350 lb.

Fig. 4 shows similar information for a 4-8-4 type steam locomotive having 80-in-diam drivers, cylinders 28×32 in., and actual static wheel loads of 37,500 lb. The graphs show that for this locomotive the static wheel load of 37,500 lb plus the dynamic augment for 400 lb overbalance will probably produce shear stress in the shatter crack zone of the rail that will be just within the prescribed stress at speed of 100 mph. With 150 lb overbalance there is a margin of safety of about 38 per cent, with a static wheel load of 37,500 lb.

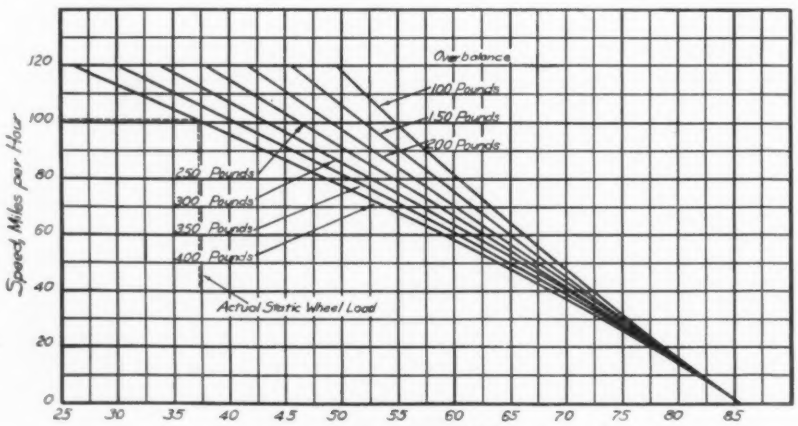

FIG. 4 MAXIMUM STATIC WHEEL LOAD ON DRIVING WHEELS AT VARIOUS SPEEDS FOR LIMIT SHEAR STRESS OF 25,000 PSI IN POTENTIAL SHATTER CRACK ZONE OF RAILS

(4-8-4 Type locomotive, 28×32-in. cylinders, 80-in. drivers, actual static wheel load 37,500 lb, variations in overbalances as indicated.)

The use of steam locomotives for either passenger or freight service is being introduced, utilizing a 4-8-4 type locomotive with 80-in. drivers, having wheel loads of 37,500 lb per driver, and with 150 lb overbalance, the main and auxiliary main wheels being fully cross balanced.

The problem of counterbalancing and particularly the method of computation is being actively studied by various railway committees. Latest information and recommendations as to proper methods of computation should be given consideration. Limitation of overbalance should be definitely recommended by equation factors with an accompanying definition of speed limitations for which a particular locomotive is designed.

Dynamic Braking. The development of the freight Diesel locomotive has reintroduced a method of braking, or rather of controlling speed of freight trains on long descending grades. Dynamic braking is essentially utilization of the power in the locomotive to hold the train by reversing the direction of the field current, by means of which motors are converted into generators and the current generated is dissipated, through resistance grids mounted in the roof, in the form of heat which is absorbed by an air cooling system. This is similar to the regenerative braking on electric locomotives, in which the current generated is fed back to the power source. The dynamic brakes are designed to hold at a definite speed on a descending grade the same train weight that the locomotive could haul up the same grade at the same speed. In actual operation, on descending grades, train weight is usually heavier and speeds maintained are higher than on the same grade ascending, so that for controlling such trains some assistance for the dynamic brake is required from the train air brakes. In trials of this brake on various grades, the amount of train air braking required was reduced to approximately one fourth of that required by conventional braking with train air brakes. The possibility for reduced maintenance owing to less wheel and brake-shoe wear is of sufficient importance to encourage further development of this brake for locomotives in mountain service. There is also a direct challenge to the steam-locomotive designers for some similar method of braking. A possible method would be in utilization of cylinder compression, the heat of compression being dissipated by evaporating water into steam.

High Initial Investment. In any discussion of disadvantages of the Diesel locomotive, the question of cost of initial investment is an important consideration in comparing Diesel against steam locomotives. Recent improvements in production methods and increasing numbers in production have gradually lowered the cost per horsepower of Diesel locomotives to approximately $87.50, while for steam locomotives of comparable horsepower costs are approximately $35 per horsepower. The higher initial cost is partly offset by the greater utilization of the Diesel locomotive, which helps to keep down the overhead cost per mile of operation.

Lower Life Expectancy. With no background other than experience in the automotive industry, the life expectancy of the Diesel engine has been estimated at a relatively lower figure than for steam locomotives. Depreciation rates are based on an assumed expectation of 15 years of service for road Diesel locomotives, and 20 years for switch Diesel locomotives, against an accepted figure of approximately 28 years for steam locomotives. Experience gained from continued use of Diesel locomotives in all kinds of service may justify an upward revision of the life expectancy at some future time. Meanwhile the low assumed figure is a definite handicap because of the resulting increased fixed charge.

Demand for Higher Degree of Maintenance. The close tolerances on numerous parts together with the complications owing to interlocking of electrical and mechanical equipment call for a higher degree of maintenance of the Diesel locomotive. On the other hand, refinements in steam locomotives such as roller bearings, improved counterbalancing for higher speeds, and additional auxiliary equipment that requires close maintenance for efficient operation add to the amount of necessary maintenance on this type of motive power. The use of road maintainers on Diesel locomotives is in question; some railroads operating Diesel locomotives consider such maintainers as an unnecessary expense. There is a direct additional operating charge where road maintainers are used, but this has been justified.

The use of maintainers on Diesel locomotives has helped to keep maintenance costs to a minimum, in that prompt attention when necessary has forestalled costly breakdowns on the road and has provided an intimate knowledge of work requiring immediate attention at terminals. The actual comparative maintenance costs of the two types of motive power are nearly equal considering that no cost records are available for general shopping of Diesel locomotives and there is a question of necessity of general shoppings for Diesel locomotives.

The lack of specially trained men and necessary equipment has been a handicap as far as keeping down cost of maintenance on the Diesel locomotive, but this handicap is being eliminated rapidly.

Higher Unit Cost of Fuel. As already noted, the thermal efficiency of the Diesel locomotive is approximately three to four times that of the modern steam locomotive. The lower fuel consumption is somewhat offset by a higher unit cost of fuel, but in spite of the higher unit cost, the net cost of fuel consumed per unit of power developed is approximately one half to two thirds that of unit fuel cost of comparable steam locomotives. In localities where unlimited quantities of good quality steam-locomotive coal are available at low cost and with little transportation requirements, the foregoing comparison might not hold good. Similarly, those railroads that are close to oil fields and refineries that can offer large quantities of residuum fuel oil at low cost cannot always justify use of the higher priced Diesel fuel oil. Conversely, in some localities where there is a scarcity of fuel, the saving in transportation charges because of the much smaller quantity required will justify the use of the Diesel locomotive because of fuel saving.

The operation of Diesel locomotives requires that fuel-oil specifications be held within a close range, which accounts in part for the higher unit cost of fuel. In the adoption of Diesel motive power exclusively, it must be remembered that other fuels are eliminated from competition. This is not the case with the steam locomotive, since with this prime mover the competitive condition existing between coal and fuel oil tends to keep unit costs at a reasonably low level. Any abrupt change in the price of either fuel immediately justifies a change by adapting the steam locomotive to burn the lower-priced fuel.

Higher Cost of Lubrication. The over-all cost of lubrication is definitely in favor of the steam locomotive. The quantity of lubricating oil required, as well as higher price, makes the net cost approximately double for the Diesel locomotive as compared with the steam locomotive. With either type of power, the lubricating cost is a relatively small percentage of the total cost of operation.

ACCOMPLISHMENTS OF DIESEL LOCOMOTIVES

A résumé of what has been accomplished by Diesel-locomotive operation in main-line service is as follows:

1 The schedule time for passenger service between important terminals has been reduced. There has been a steadily increasing number of higher-speed passenger trains placed in service by

(*Continued on page 466*)

ELECTRIC-LOCOMOTIVE OPERATION

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THE summer of 1938, just three years ago, marked the completion of the electrification project inaugurated by the Pennsylvania Railroad in 1927, over ten years before, thus bringing to fulfillment a program which has put into electric operation 675 miles of line embracing the most heavily traveled portion of the railroad system. Geographically, the electrification extends (Fig. 1) over the lines from New York to Philadelphia and Washington to the south and from New York via Philadelphia to Harrisburg on the west. It includes a number of by-pass lines which permit the movement of freight over low-gradient routes and avoid some of the more congested terminal sections.

Over the 2195 miles of electrified trackage has been constructed an 11,000-volt catenary-type trolley-wire system supplied with electric power over a network of high-voltage transmission lines feeding from the main power connections to the substations distributed along the lines. The 11,000-volt overhead-trolley-type system was selected after a thorough investigation and adequate tests extending over a period of years since the first test installation in 1908. Single-phase, 25-cycle power was selected as the most satisfactory type for the movement of heavy transportation units at high speed over a system with traffic as dense as that in the electrified territory. An indication of the traffic handled by the electrification is given by the following figures:

In passenger service, 125,000,000 car-miles are made per year, which is the equivalent of a ten-car train circling the earth 500 times a year.

In freight service, over 7,300,000 locomotive-unit-miles are made per year, hauling approximately 15 billion ton-miles of freight cars and their contents, the equivalent of a train of 100 forty-ton cars circling the globe 150 times a year.

In addition to this service handled by locomotives, nearly 15,000,000 car-miles per year are made by multiple-unit cars in suburban passenger service.

The foregoing figures represent traffic corresponding to the business of 1940. The present indications are that this traffic will be considerably exceeded during 1941 and probably by a greater amount during 1942. As far as can be foreseen this traffic will not exceed the volume which was anticipated when the electrification was planned. The railroad is making traffic volume the subject of continued study so that normal business and that required by our National Defense plans will be expeditiously handled.

To move the electrically operated trains both in passenger and freight service, there was available an average of 118 electric locomotives for the passenger service and 93 electric locomotives for the freight service. With the exception of a relatively few experimental types of locomotives, there is a total of 200 electric locomotives of two distinctly different types.

One type known as the P5a (Figs. 2 and 3) is a 4-6-4 locomotive having three driving axles with 220,000 to 229,000 lb total weight on these axles. Each axle is equipped with a twin motor geared to a quill shaft and equipped with flexible spring members engaging the spokes of the driving wheel for propulsion. The nominal rating of the locomotive is 3750 hp and is capable of producing 6400 hp for short periods of time, as explained later. The locomotives of this type are assigned to freight service and are geared for a maximum speed of 70 mph.

The second type of locomotive, known as the GG-1 (Fig. 4) is of the 4-6-6-4 type with articulated chassis and single cab unit extending over the complete running gear. The six driving axles are each equipped with twin motors, driving through a quill as in the case of the P5a locomotive. The total weight on driving axles is 300,000 lb. Nominal rating in horsepower is 4620 with the ability to develop, for short periods of time, 8500 hp. Fifty-seven locomotives of this type are equipped with 90-mph gearing and the remaining 52 are equipped with 100-mph gearing. The GG-1's with 100-mph gears are used at all times in the passenger-locomotive pool. Those with the 90-mph gearing are used in both passenger and freight service, the number available for the freight locomotive pool depending on the demand at the time for locomotives to handle adequately the passenger service. The relative number used in the two services varies from day to day.

STEAM, DIESEL, AND ELECTRIC LOCOMOTIVE CHARACTERISTICS COMPARED

Discussion of electric-locomotive operation before a group of mechanically minded engineers should include a brief summary of basic differences between the three principal types of locomotives now receiving major consideration, namely, steam, Diesel, and electric.

The horsepower of a steam locomotive is limited by the capacity of the boiler to supply steam. The maximum drawbar pull the steam locomotive is capable of exerting is determined by certain design features, i.e., steam pressure, cylinder proportions, driving-wheel diameter, and weight on drivers. Sustained drawbar horsepower is a function of the ability of the boiler to supply steam. The drawbar pull falls off rapidly as speed increases, because of the necessity of shortening the valve cutoff to keep within the steam-generating capacity of the boiler. The steam locomotive is, however, fully self-protected, in that maximum drawbar pull may be maintained without damage to the locomotive.

Diesel-locomotive capacity is determined by the horsepower available from the Diesel engine which has little or no overload capacity. If the drive between the Diesel engine and the locomotive wheels is of the usual electrical type, the electrical apparatus would be expected to have sufficient continuous capacity to utilize the output from the Diesel engine.

Electric locomotives are not limited in their horsepower capacity either by a boiler or by a Diesel engine. They obtain their power from a supplying electrical system which, when considered in comparison with a single locomotive, has rela-

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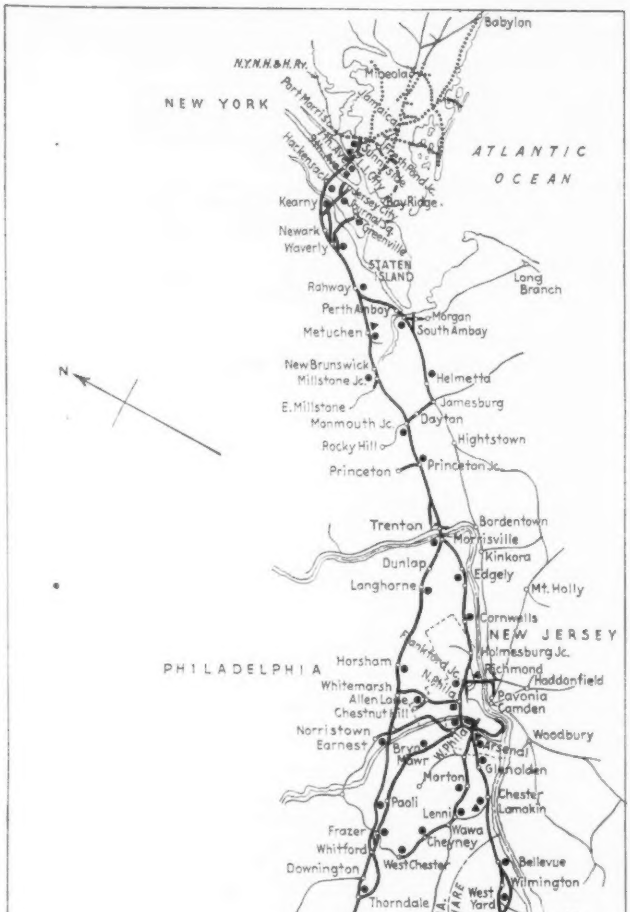

FIG. 1 MAP OF PENNSYLVANIA RAILROAD ELECTRIFIED TERRITORY

tively unlimited power. The motors are designed to deliver for short periods power approximately 75 per cent in excess of their continuous rating and this ability, backed up by a large power system, enables the locomotive to exert power considerably in excess of its continuous rating for short periods of time. This enables the electric locomotive to accelerate a train or negotiate a relatively short grade on a rolling profile at rates considerably in excess of its continuous rating. This feature is a basic difference between the electric locomotive and the other two types of locomotives mentioned, and every effort is made to take full advantage of it to obtain economical operation.

The ability to carry overloads is an inherent characteristic of electrical equipment. The reason for this is that the rating is based upon two functions, namely, the amount of power handled and the time required to heat the equipment up to its temperature limit. What is known as the continuous rating is the amount of power which can be handled for an indefinitely long period without exceeding the temperature limit. The overload ratings are based upon handling greater amounts of power for proportionately shorter periods with no greater amount of heating.

DRAWBAR-PULL-SPEED CHARACTERISTICS

Since the rolling type of profile mentioned is most common, except in extremely mountainous territory, full advantage of the overload ratings can be taken on ascending grades, since on descending grades, with forced ventilation normally designed into the equipment, cooling is rapid.

Typical curves of drawbar-pull-speed characteristics for the three types of locomotives, Fig. 5, show these features. Attention is called to the wide spread between the electric-locomotive continuous rating and the short-time maximum rating. This is significant because a locomotive seldom operates at continuous rating for any appreciable length of time. When overload capacity is available, the locomotive is generally operated above the continuous rating for short periods as required and thereby handles heavier trains. The method used for taking advantage of this feature is brought out later in the working out of tonnage ratings.

The limitation imposed on the three types by the percentage of weight on drivers that can be utilized before slipping occurs is considered the same for each and is approximately 25 per cent.

Curves of the drawbar-pull-speed characteristics of the three types of locomotives operating on a one per cent grade, Fig. 6, bring out the effects of the relative locomotive weights of the three types in reducing their net pulling capacity on grades.

The motors of electric locomotives, as well as those of the Diesel, must be protected from excessively heavy overload currents which occur at standstill and low speeds. This protection is usually supplied by overload or temperature-type relays. Under certain conditions of design the slipping of drivers when caused by the application of excessive power may also provide protection.

TONNAGE RATING BASED ON MOTOR HEATING CHARACTERISTICS

To assist in obtaining the maximum operating results from the electric locomotives, the operating departments are supplied with tonnage rating sheets for the different types of locomotives in both freight and passenger service covering the operation between the principal terminal points.

The working out of initial tonnage ratings was a vitally important prelude to starting electric-locomotive operation and its importance warrants a more detailed description. It was necessary to collect certain information as a preliminary to working out these tonnage ratings. This information was as follows:

(*a*) Curves covering the heating and cooling characteristics of the motors, the tractive effort available at different speeds and different positions of the master controller, information which was furnished by the manufacturers as a result of shop tests of the equipment.

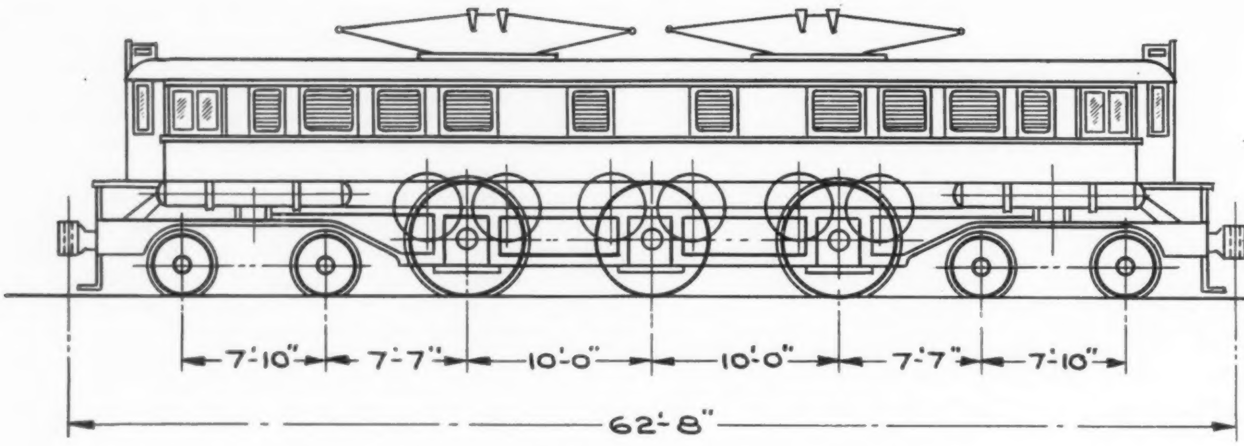

FIG. 2 GENERAL SPECIFICATION, CLASS P5A LOCOMOTIVE, 70 MPH GEARS (ORIGINAL CAB DESIGN)

Total weight	392,000	Starting tractive effort	55,000
Weight on drivers	220,000	Maximum speed, mph	70
Weight per driving axle, avg	73,333	Continuous tractive effort	28,700
Weight on each truck	85,000 No. 1 end 87,000 No. 2 end	Continuous speed, mph	49
		Continuous horsepower	3,750

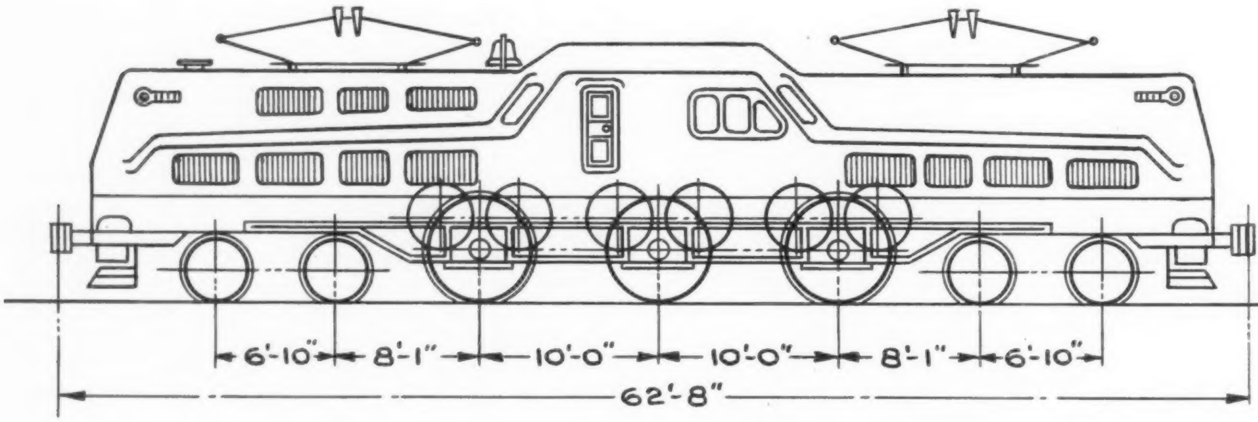

FIG. 3 GENERAL SPECIFICATION, CLASS P5A LOCOMOTIVE, 70 MPH GEARS (MODIFIED CAB DESIGN)

Total weight	394,000	Starting tractive effort	57,250
Weight on drivers	229,000	Maximum speed, mph	70
Weight per driving axle, avg	76,333	Continuous tractive effort	28,700
Weight on each truck	77,000 No. 1 end 88,000 No. 2 end	Continuous speed, mph	49
		Continuous horsepower	3,750

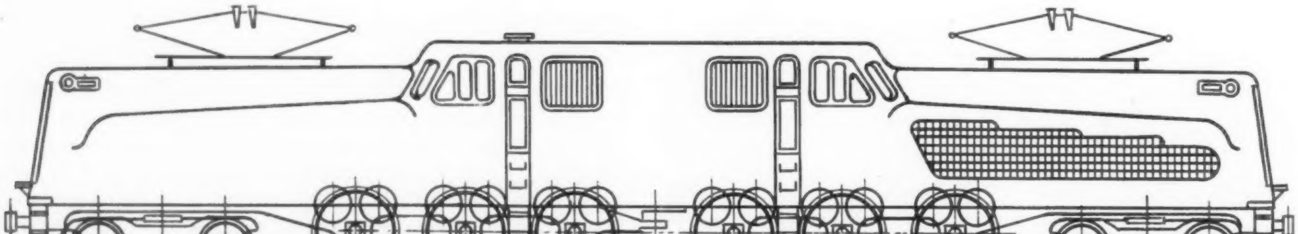

FIG. 4 GENERAL SPECIFICATION, CLASS GG-1 LOCOMOTIVE, 100 MPH GEARS

Total weight	477,000	Starting tractive effort	72,800
Weight on drivers	303,000	Maximum speed, mph	100
Weight per driving axle, avg	50,500	Continuous tractive effort	17,300
Weight on each truck	87,000	Continuous speed, mph	100

Continuous horsepower 4,620

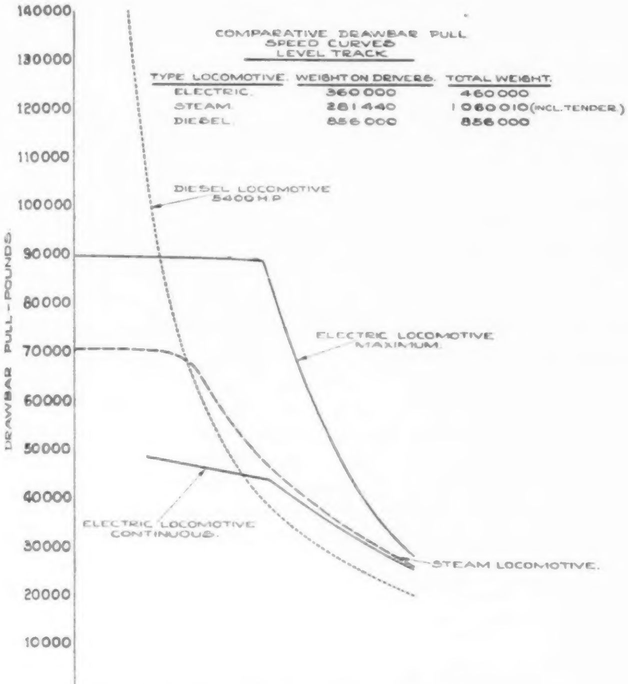

FIG. 5 COMPARATIVE DRAWBAR-PULL-SPEED CURVES OF STEAM, DIESEL, AND ELECTRIC LOCOMOTIVES ON LEVEL TRACK

(*b*) The profiles, alignments, and speed restrictions of the several routes to be used, information which was available in the timetables, operating instructions, and other records of the railroad.

(*c*) The maximum permissible temperature rise for electrical parts, which was furnished by the manufacturers on the basis of the insulation used in the equipment.

With this information at hand, a series of calculations was made for each route and each type of locomotive, as follows:

First, a tonnage was selected which it was believed the locomotive could handle over the route under consideration and stay within permissible temperature limits. Starting from the initial terminal with comparatively cool motors, a plot was made on paper of the run over the profile in a manner as nearly approaching the actual operation as possible. Accelerations were assumed to be as rapid as the engine could produce. All slowdowns and stops required by the speed restrictions or the schedule were observed. Full advantage was taken of the momentum of the train in negotiating adverse grades. A detailed record was set down of each change of tractive effort, speed, and grade, and of the distance covered and time required between such changes. By utilizing the heating and cooling characteristic curves, the temperature rise at each point on the route was determined. If it was found that the permissible temperature of the motors was exceeded at any point, the run was recalculated with a lower tonnage. Similarly, if the permissible temperature was not reached, a new calculation was made using a heavier train. In this manner the maximum tonnage which the locomotive could handle over each route without damage to the equipment was determined.

It is important to note that after the ratings had been determined by calculation as outlined, they were checked by making actual runs with temperature readings taken on the motors. These measurements have closely checked the calculations. In no case has it been necessary to reduce any of the calculated ratings.

ADJUSTMENT FACTORS FOR LIGHT AND HEAVY CARS

It is a well-known fact that the resistance to motion along the track is less per ton of weight for a heavy car than for a light car. For example, on level track the resistance in pounds per ton of an 80-ton freight car is less than half that of a 20-ton car. In other words, the force required to keep two 20-ton cars moving at a given speed would be more than enough to move one 80-ton car at the same speed. On grades, of course, this ratio changes, since the grade resistance per ton is the same for all weights of car and if the grade is appreciable, the grade resistance is a large percentage of the total. For example, using the 20-ton and 80-ton cars again, on a one per cent grade the resistance per ton of the lighter car is only about 1.15 times that of the heavier. A similar difference exists between different weights of passenger cars.

With these facts before us, it was necessary to make the series of calculations outlined in the foregoing for different trains consisting of at least two different weights of cars.

From the results of these calculations it is then possible to adjust the weight of the cars in a train by means of an "adjustment factor" which takes into account the features, such as friction and windage, which are not directly proportional to total weight of the cars. This factor is constant for any route and compensates for the aforementioned difference in resistance between heavy and light cars. The factor is worked out to be a theoretical tonnage which is added to each car of the train. Thus, the "adjusted tonnage" of a train is always greater than the actual or flat tonnage. In steam-locomotive practice, the adjustment factor is determined by the ruling grade of the route and the speed at which it is desired to negotiate the route. For example, one of our standard steam freight locomotives has a rating of 5560 adjusted tons over a given route with an adjustment factor of 10, based on a speed of 15 mph over the ruling grade. This means that the locomotive can handle about 62 cars of 80 tons each or 4960 "flat" actual tons, or about 111 cars of 40 tons each or 4440 flat tons, at 15 mph over the ruling grade.

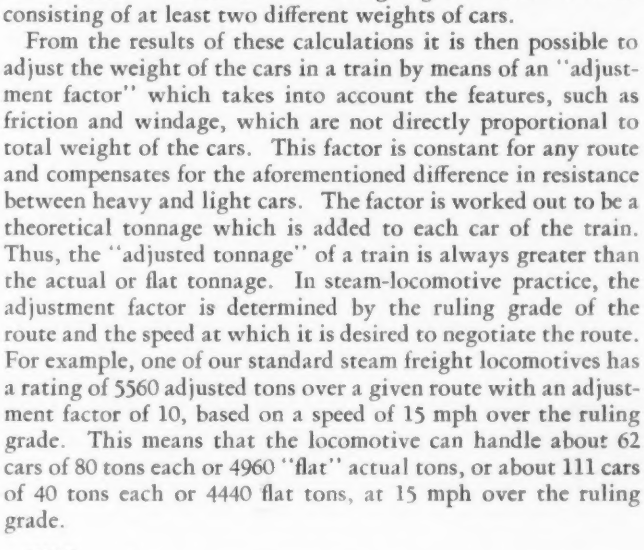

FIG. 6 COMPARATIVE DRAWBAR-PULL-SPEED CURVES OF STEAM, DIESEL, AND ELECTRIC LOCOMOTIVES ON 1 PER CENT GRADE

Inasmuch as the weights of the freight cars cover a wide range, it is not practicable to cover the freight ratings without stating the ratings in "adjusted tons" as has been done in the past for steam freight locomotive ratings. In the case of electric locomotives in freight service, the adjustment factor is not as simply determined as with steam locomotives. With different trains maximum temperature may be reached at different points in the run and consequently the entire route must be considered rather than the ruling grade alone. Thus, the tonnage which an electric locomotive could handle within permissible limits was determined for each route and for different weights of cars. If over a given route it was found that a locomotive could handle either 50 eighty-ton cars weighing 4000 tons or 125 twenty-ton cars weighing 2500 tons with the same over-all heating effects on the motors, the adjustment factor is readily determined as 20 and the rating becomes 5000 adjusted tons.

Actually, after studying all the routes it was found that for electric freight service an adjustment factor of 20 was suitable for universal use. The steam service in the same area had used values of 5, 7, and 10 for different runs.

In the passenger service the use of adjusted tonnage is not necessary, inasmuch as car weights do not vary as widely as in freight service and the locomotive ratings are, therefore, specified in terms of flat tons and cars. For instance, over the route between New York and Washington it was found that with no special restrictions on the operation of the engine, a maximum of 1445 tons could be handled by the GG-1 locomotive, but that even though the cars weighed less than about 70 tons each, not more than 20 cars could be handled on the faster schedules without overheating the equipment. However, by limiting the voltage which the engineman can apply to the motors, which can be done by restricting the operation to the sixteenth or eighteenth notch on the master controller, both the tonnage and the car limit could be raised, although at some loss in schedule speed. The complete ratings of the GG-1 locomotive in passenger service over the principal routes worked out as follows:

	No notching restrictions		18th notch		16th notch	
	Max tons	Max cars	Max tons	Max cars	Max tons	Max cars
N. Y.-Washington	1445	20	1750	27	2500	30
Phila.-Harrisburg	1330	20	1600	27	2000	30

In the operation of electric locomotives, advantage is taken of the ability to use locomotives with proper gear ratios and suitable permissible operating speeds interchangeably between the freight service and the passenger service. This results in the maximum utilization of the locomotives and permits a maximum of both freight and passenger traffic to be handled with a minimum number of electric locomotives. This is particularly true since the periods of abnormally heavy passenger traffic—before and after holidays, special events, such as the Army-Navy football game, Inauguration Day—are not days when maximum freight traffic is also handled.

Should traffic conditions warrant, it is a relatively simple matter to change the gearing on the electric locomotives to provide greater tonnage capacity in freight service. For example, the P5a locomotives were originally geared for a maximum speed of 90 mph and when they were definitely assigned to freight service the gears were changed to a maximum speed of 70 mph, thereby increasing their tonnage capacity on an average of 25 per cent with a maximum of 40 per cent on one route.

A similar increase in the capacity of GG-1 locomotives could be readily secured should the proportion of the traffic change in such a manner as to warrant definite assignment of additional locomotives in freight service.

AVAILABILITY OF ELECTRIC LOCOMOTIVES

An outstanding characteristic of the electric-locomotive operation has been the ability to obtain a high availability factor. In addition to their inherent reliability, the comparatively short time required for regular inspection is largely responsible for this result. The required daily inspections are being performed within a period of less than one hour. Few special facilities are required and these daily inspections are scheduled largely while the locomotives are at terminals awaiting trains for return movement; therefore, inspection does not appreciably affect the locomotive availability.

The regular monthly inspection on road locomotives is performed at two locations, Enola, near Harrisburg, and Wilmington, Del. This inspection requires from eight to sixteen hours per unit each month. Heavy inspections and repairs are performed on the basis of total locomotive mileage. As a result of operating experience it has been possible gradually to increase the mileage operated between heavy repairs, and the final limit has not yet been reached. On the basis of present mileage it is equivalent to approximately three-year intervals on passenger electric locomotives and five years on electric freight locomotives.

The locomotive is out of service for this work for approximately two weeks. Mechanical failures on electric locomotives have been kept to a minimum by such design features as the combining of a number of parts into one wherever possible, by the use of antifriction bearings in place of friction bearings, and by the fact that no reciprocating parts are necessary.

Because of the ability to operate the locomotives on the basis of "first in—first out" at each of the terminal points, the most efficient use of the total number of locomotives is obtained. This efficiency is further increased by the ability to move locomotives between terminal points by double- or triple-heading them to points where temporary shortage of locomotives occur, making use of the multiple operation in their control, operating one, two, or more units as one locomotive. This becomes particularly advantageous when heavy movements occur in one direction.

Typical of the improvement brought about by the operation of electric locomotives in passenger service is the schedule of the "Congressional Limited" running between New York and Washington, a distance of 226 miles, in 3 hr and 35 min, as compared with 4 hr and 15 min under steam operation with shorter length of train.

In the freight service the running time has been improved an average of two hours between the New Jersey terminals and Enola yards to the west, and in the north-south service one to two hours have been cut from the running time, depending on weight of train and type of service. This has permitted faster freight schedules and enabled more consistent meeting of schedule time.

The application of electric traction to the eastern territory of the Pennsylvania Railroad, described in this paper, was made attractive by the fact that the traffic density in this territory is great enough to warrant the expenditure required to provide the facilities for the distribution of electric power to moving trains, thus securing the high economy in power generation and motive-power units permissible with central generation of power. It has produced a faster, better, and more reliable service with fewer locomotive units and greater economy than is possible with the steam service which it replaced, and has thus placed a more reliable, cleaner, and faster service at the command of the railroad and the traveling public.

A Report to
ENGINEERS' COUNCIL *for* PROFESSIONAL DEVELOPMENT

By ROBERT E. DOHERTY

CHAIRMAN, E.C.P.D., PITTSBURGH, PA.

I—E.C.P.D. SHOULD LOOK AHEAD

THE engineering profession faces a great challenge and opportunity. It faces the imperative challenge of the unstable new world it has helped to create, and the opportunity to take a hand in stabilizing that world. But if it plans to meet this clear obligation and assume such a role in the life of the country, it should look ahead, measuring the implied responsibilities alongside its capacities for discharging them. Doing this, it would find one fundamental deficiency to be in the capacity for joint action, and another in the character and extent of the engineer's preparation. It is my conviction that these deficiencies are vital and that concerted thought must be given to their correction; otherwise the profession will probably receive and justly deserve the unhappy distinction of having let its next generation down and failed in its national mission.

Most engineers now recognize, I think, that their profession does have a heavy responsibility in the accomplishment of national stability, but they evidently do not realize that the profession is not yet fully prepared for that responsibility. I urge that it promptly address itself to the task of becoming better prepared, and I submit that there are definite ways in which E.C.P.D. should contribute to that task. At the same time, I realize that this contribution cannot be effectively made until the constituent groups reach a clearer understanding and persuasion than they now have as to E.C.P.D.'s purposes and potential usefulness.

I have mentioned capacity for joint action. The constituent bodies have of course demonstrated that they can cooperate. The formation of E.C.P.D. itself is evidence. On the other hand, there is also convincing evidence that professional cooperation has been impracticable. The termination of the American Engineering Council is an instance. The point seems to be that the groups cooperate when it is clear that it is worth while to them individually, and they don't if it isn't.

The question can reasonably be pressed, I think, whether this is now a sufficiently comprehensive attitude. Perhaps it was in an earlier period. Today, however, when problems of the engineering profession as a whole are crying for solution, when on all sides of national life extravagant insistence upon self-sufficient independence is creating centrifugal forces that tend to disrupt America, engineers must not, I urge, stand by in an indifferent isolation. They have responsibility; whether they would be or not, they are inevitably involved in both general professional and national interests, as well as in the interests of their own particular group. Clearly they should promote the solidarity of the profession so that it may be in position to deal effectively with its own general problems, but especially so that it may take a more vigorous and constructive interest in the common cause of preserving a democratic future for this country.

Constructive cooperation is at the heart of democratic life. For democracy, if I understand it, is not merely an aggregation of groups in several realms such as the political, industrial, professional. Rather it is a *system* in which these parts are *organically* related to the whole, and in so far as such a relationship does not exist, the basis for national stability does not exist. And this is the primary reason why the groups of the engineering profession should cultivate the capacity for cooperation.

The second deficiency I have mentioned is in the character and extent of professional training. To promote the professional status of engineers is to promote the effectiveness of the profession. This means better selection of engineering students, more appropriate collegiate training, increased opportunity and incentive for the engineer to continue his education after graduation, and fuller recognition of professional achievement. The full accomplishment of such a program of professional development certainly requires a cooperative effort.

There are undoubtedly other fruits of professional cooperation and other ways of cooperating, but I have outlined a way in which the profession can go ahead. For the purposes involved are precisely those of E.C.P.D.

Thus what I am urging is that the constituent organizations of the Council take a greater democratic hand in the affairs of this conference body which, with wisdom and vision, they set up about eight years ago. But I know that before greater professional interest is taken in the present work and the possible further usefulness of the E.C.P.D. in the future, the members of the constituent bodies must understand much better than they do now just what E.C.P.D. is. Some think that it is merely an accrediting agency for engineering curricula; others are aware that it has additional functions but feel that it has accomplished little except in the field of accrediting; a great many fear that it is ambitious to become a superbody which may try to usurp powers of the constituent Societies; and there are, of course, those who do not know or care what it is all about. Then there may be others I have not heard from. So there should be an educational campaign by the several engineering groups to acquaint their memberships with the purposes and work of the Council.

E.C.P.D. is what its charter says it is. This charter is a great document of engineering statesmanship that clearly points the democratic way toward the further development of the solidarity and prestige of the profession. It says, "The E.C.P.D. is a conference of engineering bodies organized to enhance the

A report to the constituent bodies of E.C.P.D. by the chairman of the Council. Received by the Council of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS and authorized for publication, at the Spring Meeting, Atlanta, Ga., April 1, 1941.

professional status of the engineer through the cooperative support of those national organizations directly representing the professional, technical, educational, and legislative phases of an engineer's life." To this end it aims to "coordinate and promote efforts and aspirations directed toward higher professional standards of education and practice, greater solidarity of the profession, and greater effectiveness in dealing with technical, social, and economic problems."

Thus E.C.P.D. is immensely more than an accrediting agency. True, as such an agency it has been eminently successful in doing an extremely difficult job that might, in less able hands, have ended in confusion. In comparing this with other Council projects, however, one should remember that, whereas the completion of an accredited list of curricula is the kind of assignment that can be carried out in a few years, the purposes involved in other projects are most of them of a kind that cannot be achieved promptly; they look to the long run and require continuing negotiation, study, and research. Hence the current results of the other projects, however important they may actually be, do not appear spectacular. But this fact should not be misinterpreted. These projects conceivably may be in the long run even more important to the profession than accrediting.

In the approach toward the goals of E.C.P.D., the value of new sources of counsel and support is obvious. A significant advance was made in October, 1940, when The Engineering Institute of Canada was welcomed into the Council as a constituent member. This new expression of common interests with Canadian engineers will afford a liaison which will assure the fullest development of those interests in both Canada and the United States as they relate to the purposes of E.C.P.D. The assurances that I have from the Institute regarding the benefits to the engineering profession in Canada from the work of the Council are very gratifying, and the Council has profited by the presence of its new members.

A final important fact should be emphasized: With the American Engineering Council now defunct, E.C.P.D. is the only body which is in position, by reason of direct representation of professional, technical, educational, and legislative interests of the engineer's life, to deal effectively with the broad problem of professional development. It has already taken over from A.E.C., for instance, the functions of that Council's Committee on Professional Ethics. The member groups, however, will bear in mind the fact that E.C.P.D. is an advisory service organization, wholly responsive and responsible to its constituent bodies; and the Council must be cautious to confine itself to matters strictly within the scope of its charter and to avoid the danger of spreading itself too thin. But the fact remains that if cooperative progress is to be made by the engineering organizations, E.C.P.D. is now the only central medium through which that progress can be made.

II—MEMBERSHIP AND ACTIVITIES

A complete understanding of the Engineers' Council for Professional Development must include a knowledge of its constituency as well as the work in which it is engaged. Here emphasis should again be placed on the fact that the Council has functions of advice and recommendation only and does not administer any project unless it is definitely approved by a majority of the constituent groups.

The constituent bodies include the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, the American Institute of Electrical Engineers, the American Institute of Chemical Engineers, the Society for the Promotion of Engineering Education, the National Council of State Boards of Engineering Examiners, and The Engineering Institute of Canada.

The work of the Council is indicated by the activities of five principal committees. Concerning these activities I append brief reports for which I am indebted to the respective committee chairmen.

1 *Student Selection and Guidance.* Recognizing the importance of providing for interested young men information concerning the mental, physical, and personal requirements for a reasonable future in the engineering profession, the Committee on Student Selection and Guidance is organizing committees of engineers to meet with those high-school boys who have made inquiries concerning the study of engineering. Probably 8000 boys attended such meetings last year. In carrying on this work the committee has received valuable support from the secretaries of the national engineering societies holding membership in E.C.P.D. and from the local sections or committees of these societies. Local and state engineering societies have also aided. Moreover, the public schools, except in one city, have welcomed the help of engineers in giving information concerning the education and work of men in our profession. Gratifying reports have been received concerning the helpfulness to the high-school boy of such personal contact with a practicing engineer.

Linked with the problem of providing adequate guidance to prospective students is that of making possible the selection of better engineering talent. The committee is studying means of measuring more effectively scholastic proficiency and personal fitness for collegiate and professional training. In order that entrance into the study of engineering may be confined to those likely to succeed in it and that as a result withdrawals may be reduced, the committee is urging higher standards of admission to engineering schools.

To succeed the pamphlet "Engineering: A Career, A Culture," published by the Engineering Foundation in an edition which is now nearly exhausted, the committee has prepared for publication another entitled "Engineering as a Career." The usefulness to E.C.P.D. of such a publication on guidance is great.

2 *Engineering Schools.* This committee, for the first time in the history of our profession, has appraised in an unbiased manner the programs of study of engineering schools, and has prevented a multiplicity of accrediting agencies in the field of engineering education by preparing a list of 542 undergraduate engineering curricula in 125 institutions. One hundred and sixty-four curricula were inspected but not accredited, and action on three curricula is pending. Though the major portion of the program was completed by October, 1939, the activity of the committee during the last year has included the reappraisal of 70 curricula not previously accredited and the inspection of 32 curricula not on the accredited list of October, 1939.

The basis for accrediting has been a sound educational program, and inspecting committees were cautioned against undue standardization or forced regimentation of engineering education. Quantitative criteria were subordinated to qualitative factors as a measure of the soundness of a program of study.

The visits of inspection by E.C.P.D. committees since 1935 and the friendly advice given to engineering schools, when requested, have in these cases resulted in higher entrance requirements, better curricula, more adequate facilities in building and equipment, and improved as well as enlarged engineering teaching staffs.

An analysis of the data gathered by the Committee on Engi-

neering Schools and a report thereon were made by Prof. D. C. Jackson at the instance of the Committee, with the financial support of the Carnegie Foundation for the Advancement of Teaching, and published in the year 1939 as a pamphlet entitled "Present Status and Trends of Engineering Education in the United States." A copy was sent to the office of the president of each institution supporting an engineering school on the accredited list, to each dean of an engineering school on the accredited list, and to the libraries of such schools. Other copies were made available through the headquarters of E.C.P.D.

3 *Professional Training.* Professional training is part of the continuing processes of education that are but barely begun in the engineering schools. In the first few years after graduation, the young engineer finds his most serious challenge. If he is to continue to advance in the profession, he must do more than acquire the technique and practices of his immediate job. His future will often depend as much on the knowledge and experience he gains through contacts with fellow engineers, through working with them to broaden his understanding of the engineer's position and responsibility in society.

To aid junior engineers in this critical phase of their development is the function of E.C.P.D.'s Committee on Professional Training. Working with the local sections of the constituent societies, it has encouraged the organization of many junior engineering groups throughout the country. Most of these have for their chief objective improvement in the professional status of their members through study courses, lectures and discussions, plant visits, and inspection trips. Self-analysis questionnaires and suggested reading lists of both engineering and nontechnical literature have been prepared by the E.C.P.D. committee for the use of these junior groups. In some communities the committee has cooperated with the engineering schools in organizing and publicizing their extension courses. And now that the National Defense Program has stimulated many companies to set up training courses within their own plants, the committee is finding a still greater opportunity to help young engineers to take root and grow in the profession.

4 *Professional Recognition.* Professional recognition is a normal goal following the attainment of an engineering diploma and professional training in the school of experience. This committee is concerned with "methods whereby those engineers who have met suitable standards may receive corresponding professional recognition." The principal agencies according recognition are engineering societies (independent and autonomous, and differing in their requirements for membership) and state engineering registration boards, operating under different laws in seven eighths of the states. E.C.P.D. has set up as a "suitable standard" certain minimum qualifications for an engineer—including education and capability developed in practice—which are generally accepted and afford a basis for common requirements for society membership and legal registration.

Professional recognition—the goal of education and experience—implies entrance into the engineering *profession*, and the young engineer should understand just what his profession is and what are its privileges, opportunities, and responsibilities. But just what is it? It is not a single organization or a unified group. Its development has come principally through many societies devoted primarily to technical advance in their respective fields. This development, while fruitful in technical progress, has not promoted professional solidarity. It is true that recently legal registration by the states has created a new grouping on the basis of competency, but though the 70,000 registered engineers about equal the total membership of the older societies, a majority of each group does not belong to the other.

In its recent annual report the committee urges that our societies make "a study of the engineering profession including its present status and development" and seriously consider whether their "profession can adequately meet its obligations and opportunities as an aggregation of individual groups, loosely linked by numerous common agencies." It also urges that our societies encourage their student groups to become "interested in a study of engineering as a profession, including its present status and its development; also the field of professional ethics." The ideas and ideals implanted annually in 10,000 engineering graduates leading them to distinguish engineering as a profession from engineering as a technical occupation may give the coming generation a better profession than we have known.

The committee is planning to take up directly with the proper officers of the several societies the carrying out of the general projects aforementioned.

Summarizing, the general objective of the committee is to develop a proper understanding of what constitutes the professional status of the engineer as a basis for professional recognition and to help engineering students to an appreciation of professional attitudes and conduct.

5 *Principles of Professional Ethics.* This committee was originally sponsored by the American Engineering Council, and upon the discontinuance of that body the sponsorship was taken over by the E.C.P.D., additional members having been appointed in order to provide representation for all the constituent Societies of the E.C.P.D.

Prior to this change in organization, the committee had undertaken a study of existing codes of ethics in the engineering field and had considered the advisability of a universally accepted single code and the form which such a code should take.

Though progress has been slow, as is natural where communication must be carried on mostly by correspondence, there is now being formulated a preliminary draft of a report on a code of ethics for guidance in the engineering profession. This report will contain (1) a preamble briefly stating the origin and the need in intimate life of canons of ethics, (2) a statement of underlying principles, (3) a statement of reasons for excluding from the present code business rules of practice, and (4) a specific code for ethical conduct.

The object of this study is to bring to the attention of prospective and practicing engineers an ethical code, generally adopted, which may stimulate the minds of students and the younger engineers toward ethical thinking and may supply to mature engineers information regarding what their Societies expect of their professional conduct.

If such a report, when completed, is approved and recommended by the E.C.P.D., the committee feels that the governing boards of the constituent Societies may come to adopt it as their individual and collective expression concerning the field of ethics and that it may gradually be adopted by the local engineering societies, with the result of a very definite contribution to the solidarity of the engineering profession.

* * * * *

The foregoing brief review of the composition, opportunities, and current activities of the E.C.P.D. indicates something of the Council's fitness and of its officers' plans for putting into effect the objectives of its charter, as well as something of the progress already made. Looking ahead, the Council is, I think, justified in the hope that with the active interest and adequate support of the constituent bodies it may serve engineers increasingly in the cause of professional development.

THE FUTURE THROUGH MR. BERLE'S EYES[1]

By FRANCIS S. DOODY

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SINCE the advent of the Roosevelt administration academic circles have been able to point with no little pride toward the increased willingness of political leaders to lend an interested ear to the Professor. The significance of the process of endowing political measures with intellectual respectability depends, of course, upon the quality and not upon the number of advisers.

One of the better men, one who has participated not only in the dissemination of ideas but also in the implementation of those ideas, is Professor Adolf A. Berle, Jr., now Assistant Secretary of State and on leave from Columbia University, where he is Associate Professor of Corporate Law. Professor Berle, in his recent publication entitled "New Directions in the New World," gives us a picture of the current state of his thinking on many of our domestic and international problems.[2] His thinking, always stimulating, is now of added importance because of the clues that it may give us to future governmental policy.

The book falls naturally into three portions: The first discusses American international relations, with particular reference to the not unrelated problems of international trade and South America; the second deals with domestic economic issues in a democracy; and the third contains Mr. Berle's specific proposal for an improved banking system.

I

Mr. Berle shares the nineteenth-century liberal's complete faith in the virtues of free trade. The seductive power of the principle of specialization has lured economists since the day of Adam Smith and his pin factory, and as a general principle there is, of course, nothing to it—free trade wins hands down. Furthermore, in a world fraught with rampant nationalisms, free trade gains added significance as an instrument of peace. But the general principle needs to be tested in specific cases and in certain of these it does not serve as an adequate guide to policy. The most crucial case occurs in connection with the transitionary period to freer trade; here it is important to devise additional methods of lowering trade barriers and of making the necessary transitional adjustments internally. This is recognized at least partially by the reciprocal trade agreement program (shelved, of course, "for the duration"). A second case, important particularly in connection with domestic problems, should be noted. A fairly good argument may be made for tariffs which vary inversely in height with the state of domestic business activity and thus operate to increase the volume of new investment which is desirable in times of depression.

The postwar period will very likely see Mr. Berle's problem of selling freer international trade to the world an increasingly difficult one. We may then expect demands for higher tariffs to continue the shelter given by war blockades to both old and new industries. Another source of difficulty may occur in an attempt to continue the war in an economic sphere by competitive tariff races and measures to prevent dumping.

We should do well at this point to question whether even a peaceful world is justified in expecting a future tendency toward an increase in the per capita volume of international trade. Some of our leading economists believe that the answer to this is in the negative. The successful development of substitute products and the ever-continuing phenomena of technological change, which in some cases works to reduce the force of comparative advantage, seem to point toward this answer; and, as we know, these factors receive added impetus from the demands of war strategy. A trend toward a declining rate of growth in the per capita volume of international trade would reinforce the free-trade argument except in so far as technological developments place many goods on the margin of being traded or not being traded. In this event the volume of international trade might be affected by events of relatively small magnitude and domestic economies subjected to fairly frequent and severe buffetings. In the event of such a trend the obvious policy is one of mild protection.

The author depicts vividly the postwar job of reconstruction that will be necessary in Europe. Upon the cessation of hostilities, ". . . we shall be faced immediately with the task of dealing with great distress overseas, and we shall be fortunate if we do not have some at home. (This) means that we shall be sending goods which we produce in abundance to places where they are needed. We may, and no doubt will, hope that we shall be paid for them some time; but we shall know that, paid or not, human suffering must be relieved." (Page 4.)

From the vantage point of a later date than that of Mr. Berle's writing, it is possible to visualize more clearly the magnitude of the coming postwar depression. Unless we lay careful plans, the effective choice presented America in the immediate postwar world may be between feeding its own unemployed and feeding a war-torn Europe. The allocation of funds and the production of nonmilitary goods will be the dual phases of the problem.

An alternative, suggested by Mr. Berle and having the additional merit of further cementing our South American relationships is "for us to buy and store considerable quantities of certain of the key products of which this Hemisphere has a surplus, and for which we know there will eventually be need." Furthermore, "The immediate effect of this will be that the countries in this Hemisphere need not find their economic life endangered because they are temporarily cut off from certain of their markets." Finally, "The principal effect, so far as we are concerned, of buying South American surpluses will be to increase the markets for United States goods." (Pages 11–12.)

In the area of American diplomatic relations the author points out the contribution that the Western world has made to the technique of handling international affairs in what he terms "Cooperative Peace." This idea has been more precisely formulated in recent years, and under it peace has been enjoyed in a larger area, by more millions of people, and for a longer period of time than in all recorded history. The maintenance of this Cooperative Peace, he points out, requires "endless and often unspectacular work of so handling the relations of the American family of nations that they shall be secure, independent, and free, both in their economic and in their political life." (Page 10.)

In 1938, the twenty-one republics of this Hemisphere, assured reasonably of the status of their internal organization, took a

[1] One of a series of reviews of current economic literature affecting engineering, prepared by members of the department of economics and social science, the Massachusetts Institute of Technology, at the request of the Management Division of The American Society of Mechanical Engineers. Opinions expressed are those of the reviewer.

[2] "New Directions in the New World," by Adolf A. Berle, Jr., Harper & Brothers, New York, N. Y., and London, England, 1940.

stand in external affairs. The Lima Conference asserted the intent of the American nations to defend and maintain their independent institutions against all comers and to cooperate to that end. Furthermore, these republics agreed to consult as to the measures which might be necessary whenever it appeared that the American peace might be disturbed.

Despite these declarations many American observers have been uneasy concerning the possibility and the extent of Fascist penetration south of us. In reply to this contention, Professor Berle says, ". . . the bulk of South America, like ourselves, appears to wish to be in the orbit neither of Fascism nor of Communism; to preserve for its citizens, as well as it can freedom to choose their own 'good life.' . . . the continued existence in various countries of governments which claim sanction from something other than majority vote of all individuals of full age is hardly a basis for classifying great parts of the continent as having taken sides in the struggle between international ideologies. Still less is it wise to draw political conclusions from purely commercial activities. Too often the argument runs that wherever a German or Italian sale is made, the German or Italian political influence necessarily follows." (Page 30.)

II

Professor Berle terms the main problems of the decade of the thirties as four: The problem of youth, the problem of unemployment, the stifling of the small businessman, and the problem of old age. Here we are all familiar with the government's attempts at solution, and, although evaluation of the success of most of these measures awaits further research, we know that the job is still uncompleted. In Mr. Berle's words, ". . . the government's work will not be done until every American has a reasonable opportunity at all times to have a job, and to have a home, and to have it without being required to abandon his liberty, his individuality, and his choice of the way he lives his life." (Page 54.)

Two aspects of the general problem of governmental intervention in the economic life of its citizens need discussion here. The first relates to the extent to which the government may impede the operation of the capitalist machine, the limit at any one time which federal activity cannot transgress without impeding the operation of that machine; while the second phase refers to the possibility of modifying that limit by the educative process.

To achieve an increased per capita volume of output of goods and services, capitalism relies initially upon a continued flow of investment in new enterprises and ultimately upon the development of innovations which open opportunities for new enterprises. These innovations may occur in the form of development of new products and new processes, shifts in consumer demand in favor of a hitherto neglected industry, and the opening of new markets and sources of supply through discovery, through improved means of transportation, or through lower tariff barriers. The stimulus to the investment in new enterprises lies, of course, in the lure of profits. Thus the crucial question that must be raised in connection with governmental intervention in the aggregate as well as with specific political measures is to inquire as to the extent of diminution of the lure of profits. This may occur either through the taxation of those profits in amounts sufficient to render the assumption of risks undesirable or through the (intentional or otherwise) creation of an air of hostility between government and business.

A useful classification of kinds of governmental activity with respect to their effect upon the economic process would be the following: Those measures that facilitate the operation of the capitalistic machine, outstanding examples here seem to be the corporation acts, the patent acts, and the exchange stabilization fund; those measures which check the further development of the undesirable characteristics or "excesses" of capitalism, for example, the Wagner Act, the Public Utility Holding Company Act, and many of the "reforms" of the New Deal; and finally, measures which impinge directly upon the capitalistic process, either in the creation of an atmosphere uncongenial to that process or in the removal by taxation of the profits which the process holds out as reward for further development. It is of course possible, and in many cases probable, that any single measure will carry effects which will necessitate its classification under more than one heading.

The governmental interventionist must recognize that much of his general activity and in particular his fund-raising activity operates in a manner which inhibits the workings of the capitalistic machine. While this may impress the reader as a restatement of certain bits of campaign oratory, it is but pointing out a fact inherent in the nature of the capitalistic process.

This does not mean that action is denied the would-be preserver of capitalism. It does mean that political measures must not be hastily drawn and that they must be constructed with an eye toward their context in the entire social and economic process. The limits to governmental intervention are fairly flexible, particularly as background conditions change. Thus, in the emergency atmosphere of a war, the limits are pushed far to the left, from which point they never quite recede to their original position. In normal times a general program for the education of the businessman seems to be called for. This should run in terms of a growing appreciation of the social responsibilities and social costs of business enterprise, as well as private responsibility and private cost.

Mr. Berle recognizes this latter problem when he says, "We may inquire, for example, what is the most desirable size for an industrial plant. It may well be that the very large plant, though attractive at first, will cost more than it is worth because of the social problems which it creates, problems for which individual communities must ultimately pay. It must be remembered that industry is always more or less driven by economic currents, which few can chart; and that when the plant cannot run, the community has to take over. A plant is potentially wealth of a high order. It may also represent a staggering potential burden, which the community must be prepared to assume." (Pages 57-58.) His solution of the problem does not run, however, in terms of expanding the acceptable limits of governmental intervention, but rather in a more specific proposal, which we must now discuss.

III

The author's analysis of the business-cycle problem, which is always with us, runs in terms of the paradox of excess productive facilities and deficient distributive facilities. He points to the "plate-glass window" which exists between an overplus of supply and unmet needs. As long as this exists, he suggests that the credit and banking machinery must be subjected to constant study. Capital needs to be provided in order that new production, new industries, new goods, and new services may be developed. "Credit, today, is the modern equivalent for the old quarter-section of undeveloped land." (Page 61.)

The problem lies essentially in the fact that, "American private markets are not funneling capital funds into capital construction at more than (roughly) one third to one half the rate they were doing in the last decade. This means that private activity in heavy industry is not being continuously generated in sufficient volume to keep those industries busy, or to

keep the country continuously on an even economic keel." (Page 101.)

He suggests a "system of capital credit banking" to solve this problem. Such a system would make available at all times an adequate supply of cash and credit for investment purposes; it would provide funds for noncommercial or public projects as well as the commercial; it would lower long-term interest rates in times of depression; it would set up selective interest rates as between commercial projects and, say, a hospital. The system might be under nonpolitical public control, or might have some elements of private control. "But it is essential that the capital credit which it supplies shall never be cut off merely through private motives."

The most important question here relates to the kind of securities such an institution would be allowed to purchase. It is difficult to see how a conservative policy of purchasing only high-grade securities would serve to melt a frozen capital market. The purchase of the more speculative new issues seems to be what is desired, yet it is here that the test of the securities market is most needed, in order to sift out the most undesirable projects and allocate funds and resources to those with the greatest chances of success. It is not without some misgiving that we envisage government entrance into this area. The alternative would seem to be to steer speculative securities in the direction of those members of the public who are willing to accept large risks in the hope of large gains; and this could be accomplished by a somewhat more lenient government attitude toward present capital markets.

The final question which we wish to raise concerning this suggested solution for our business-cycle problems is whether financial difficulties really lie at the base of the problem. The alternative solution to the problem which has gained broad acceptance among economists lies in the thesis of declining investment opportunities, an argument which may be stated in several ways. Any statement, however, lays emphasis upon the factors influencing the demand for investment funds and calls primarily for the appearance of new industries to carry forward the output curves of the capitalist system. Mr. Berle's suggestion to improve the supply situation of capital funds, when viewed in this light, seems not to deal with the fundamental problem. At the conclusion of the war the unpleasant issue of declining investment opportunities may again arise, and fortunate indeed would be the American economy if the creation of a capital credit banking system provided the answer to the problem.

Operation of Steam Vs. Diesel-Electric Locomotives

(Continued from page 455)

various railroads, all of which have proved to be popular with the traveling public. Incidentally, some railroads which inaugurated higher-speed service utilizing steam motive power initially have since changed to Diesel power for this fast service.

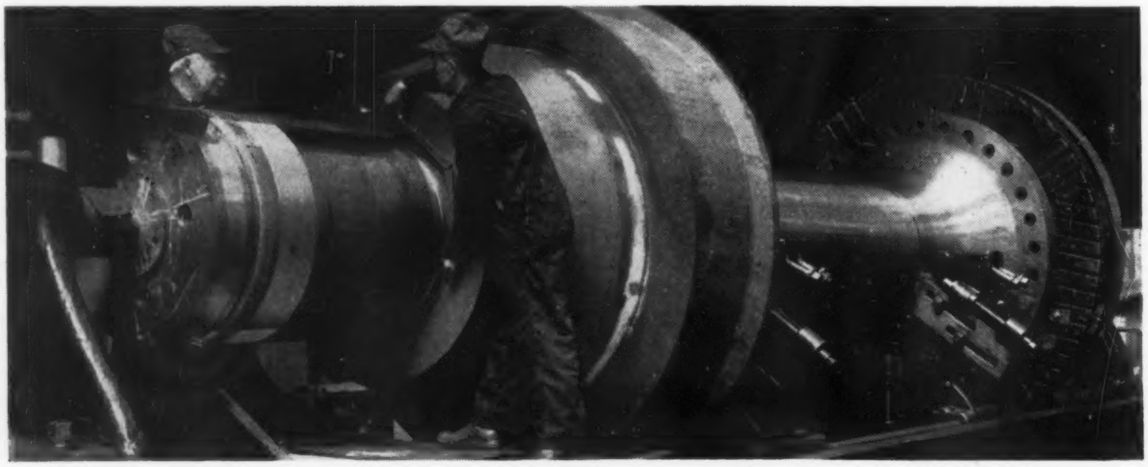
2 In freight service, it has been possible to increase both the tonnage hauled and the average speed between terminals. The power performance particularly in the lower speed range has made it possible to operate trains over most ruling grades without need for helpers or for double heading.

3 In bad weather with adverse rail conditions, the Diesel locomotive because of uniform torque on driving wheels and distribution of available tractive effort over a greater number of driving wheels has demonstrated its ability to maintain schedules without reduction in weight of train handled.

4 The Diesel locomotive has shown the possibility of long locomotive runs, with very little service required for locomotive at intermediate division points. It has directed attention to the fact that the only economical operation is obtained from motive power that is moving. Indirectly, attention has been focused on terminal delays to freight trains and also to the need for improvement in getting trains through divisional terminals.

5 It has stimulated the energies of the steam-locomotive designers to develop steam motive power that has performance characteristics to compete with those of the Diesel locomotive. At the present time there is a need for an all-purpose Diesel locomotive that can be utilized in either freight or passenger service, and which will fit with steam-locomotive helpers where such helper service is required.

In conclusion, it would be farfetched to intimate that the Diesel locomotives will displace steam locomotives altogether in railroad service, but they are definitely a part of the picture. As more and more of them are built, there undoubtedly should be a decrease in the unit cost. This will narrow the gap now existing in the relative initial investment of the Diesel versus the steam locomotive. At the same time, it is to be expected that competing steam locomotives will have considerably improved performance characteristics to match those of the Diesel locomotive.



MEN AND MACHINES AGAINST TIME

(Turning shaft of 30,000 kva water-wheel generator at Allis-Chalmers Manufacturing Co.)

BRIEFING THE RECORD

Abstracts and Comments Based on Current Periodicals and Events

MATERIAL for these pages is assembled from numerous sources and aims to cover a broad range of subject matter. While few quotation marks are used, passages that are directly quoted are obvious from the context and credit to original sources is given.

Science and Human Prospects

SCIENCE

IT IS unfortunate that lack of space prevents reproduction in full of the address of the retiring president of the Geological Society of America, Prof. Eliot Blackwelder, of Stanford University, delivered at the annual meeting, Austin, Texas, on December 26, 1940, bearing the title "Science and Human Prospects." The following passages are quoted from *Science*, April 18, 1941.

It seems to me that a teacher of geology, or indeed of any other science, should devote himself not only to giving his students information, and explaining processes and theories—however important those educational duties may be—but especially to training young people in the scientific way of thinking and helping them to acquire the scientific spirit. To my mind, this is his most important function . . . . .

The scientific method is relatively new. As recently as four centuries ago it was not in vogue even among the most learned thinkers of the time. Today it is used only incidentally by most of the people in even the most civilized countries. It is hardly an exaggeration to say that the majority of educated persons—even those with college degrees—do not really understand it. Often it is confused with invention or the mere cataloging and classifying of knowledge. . . . Science is not invention. The purposes of scientists and inventors are fundamentally different, even when they use similar methods. . . .

The critical testing of ideas, though a fundamental practice of the scientist, is a habit difficult for the average human being to adopt. An original idea is a brainchild and tends to be jealously cherished as such. To expose it to the cold light of reason takes a sort of Spartan courage that is too often undeveloped and yet is one of the essential attributes of anyone who aspires to be called a real scientist. To be merely logical with facts selected for a purpose is much easier than to divest oneself of bias. Steadfast courage and a renunciation of false pride are required in the search for opposing rather than supporting evidence. . . .

That the scientific method had its beginning in the ancient Greek and probably even earlier civilizations is clear enough, but it was displayed by only a few of the philosophers of that era and not consistently even by that few . . . . .

It must be admitted that dogma has been the fashion of the past. For millions of the earth's inhabitants it still remains so. Today we see the current of progress being reversed in the despot-ridden countries of Europe, where the privilege of freely drawing conclusions from evidence is being restricted and the blind acceptance of official dogma is exalted as a duty if not a necessity. . . . .

Fortunately, rancorous disputes have nowadays largely

WOMEN AND MACHINES AGAINST TIME

(Frame of a 40,000-hp Westinghouse fan motor that will drive the fan to circulate air at 400 mph in the new 616-ft wind tunnel of the U. S. Army at Wright Field for testing full-size plane propeller and engine enclosures. The women shown are putting the finishing touches on the windings.)

ceased to afflict the relations of real scientists. Yet there is still far too much of that spirit in the world at large. It has been well said that "Most men think with their emotions rather than their intellects." The ancient method of verbal combat is still employed in our law courts and legislative halls. Each participant adheres to his thesis. Search is then made for evidence to support it and at the same time to refute its opponents. An equal effort is made to suppress or depreciate any facts that may prove to be embarrassingly adverse.

The debating society may be a good place to train lawyers, but the partisan attitude of "win the argument and confound the opponent" is an unhealthy state of mind for a young scientist. Indeed, he can never become a true scientist until he outgrows that mental habit. Rather he should cling to the advice of the wise old Quaker, William Penn: "In every debate, let *truth* be thy aim, not victory." Perhaps it is our sporting instinct, derived, it may be, from our age-long struggle against each other, that makes us usually more interested in winning a contest than in finding the truth. . . . .

Along with the increasing complexity of modern life there has grown up an urgent need for the scientific expert. The de-

mand is being met by many persons who are real scientists but, unfortunately, by others who do not deserve the name. . . . .

Since the public must depend on its experts, it is essential that it should be well justified in placing confidence in them, to the end that such respect will endure. That puts a heavy responsibility upon the individual expert. As Grover Cleveland once said that "a public office is a public trust," no less so should any degree of leadership in science be regarded as a public trust; and so the expert scientist is under great obligation to deserve the confidence of the public. His intellectual honesty will need to be outstanding and unwavering. Today, in this country, the scientist has already won such esteem to a large degree, although he is compromised and discredited now and then by the shortcomings of the less conscientious and careful of his colleagues.

Many years ago, a former president of our society, R. A. Daly, speaking informally as a visitor to one of my classes, advised the boys to "think to scale." It would be hard indeed to pack more meaning into three words. The person who *thinks to scale* sees the relative value of each fact he uses and of each objective before him. He can then economize his time by confining his attention chiefly to the important and significant problems. . . . .

More than three centuries ago Sir Francis Bacon urged the application of the scientific method, as he then conceived it, to human affairs and problems in general, but we are still far short of having adopted his advice, although all our experience since his day confirms its value. The greatest progress has been made thus far in the physical sciences and scarcely less in the biological. The scientific method and attitude of mind also pervade to a very large degree the related professions of engineering and medicine. . . . .

In such fields of study as economics and sociology, the complex and fluid nature of the basic data that must be used and the influence of human prejudice, which closely touches these subjects, has greatly impeded their emergence from speculative philosophy and their rise toward the scientific level. In addition they need a more general adoption of the scientific attitude and method. Can we not apply these to human affairs, subdue the emotional considerations, and brush away the errors of the past? Then we should be able to move more rapidly toward a real understanding of principles, for we are justified in believing that such principles do exist.

But for the deficiency of science in politics, statecraft, and ethics perhaps we should not find ourselves now threatened by the plague of military despotism, which is more deadly in its modern form than any pestilence. We have used the scientific method in engineering and medicine for a century and have found it good—far more effective than the old ways of speculation or of trial and error. In spite of the difficulties involved why not then extend it to other fields?

To have science flourish, there must be complete freedom of inquiry and discussion. The beneficial influence of such freedom is indicated by the extraordinary development of philosophy and the sciences among the Greeks in the fourth to sixth centuries B.C., in the Germany of the nineteenth century, and in modern America. Scholars properly insist on this necessity and guard their hard-earned right to intellectual liberty; nor is this freedom of research so firmly held but that it takes a little defending, all the while, from the bigots who would close to discussion certain trends of thought of which they chance to disapprove.

But if the scientist is to deserve and therefore keep his freedom, even in a republic, he should be equally scrupulous about his own responsibility to the public. He has no right to claim on the one hand immunity from restraint, and on the other hand license to be unreliable. It is the less responsible members of our profession who most endanger our freedom of thought, for it is their words that tend to discredit the very science to which they are nominally attached and thus bring all science into disrepute. . . . .

To be good, a system of education must be suited to its time in history. The boys of ancient Persia were taught "to ride and to shoot and to speak the truth." In their day, nearly 3000 years ago, that was education enough, but now it would be of little avail, although the last item (speak the truth) has eternal value.

If we were willing to accept the "Nazi" plan of society we should need only a small highly educated upper caste. The rest of the people would be given only training and indoctrination. But if we want freedom and the so-called democratic way of life, then we need the most widespread and effective education that our mental equipment will

MEDIUM M-3 U.S.A. COMBAT TANK

(First of the new tanks being manufactured by the American Locomotive Company turned over to the Army on April 18 is 18 ft long, weighs 28 tons, is driven by a 400-hp air-cooled radial gasoline engine, and is capable of a sustained speed of 25 mph. Fire power includes a 75-mm and a 37-mm cannon and several machine guns.)

permit. In our own system, a few wise leaders would be helpless in the face of a grossly ignorant populace, swayed chiefly by its emotions and prejudices. Too often this has been true in democracies thus far, and in America it is still a dangerous factor. So I conclude that we must have, as soon as we can provide it, far better and more extensive education, and a general adoption of the scientific attitude of mind. Is that a large order? It surely is—perhaps too much to expect—but it may well be the price of our liberty and the survival of our own type of civilization.

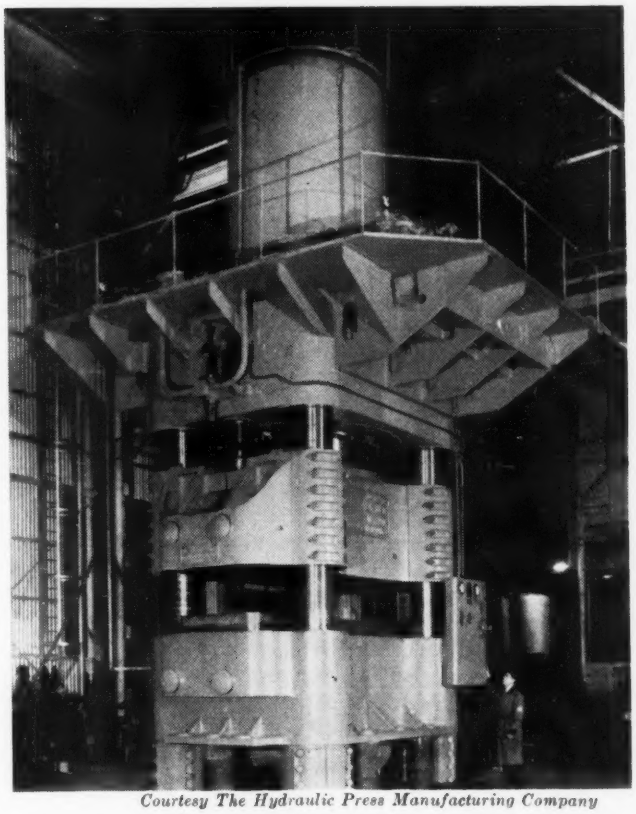
Hitler is quoted as having said that no people is capable of governing itself or even of planning its own affairs. If the majority of the people are to be kept in ignorance, he is doubtless right. As our life becomes more complex our problems become more difficult. To solve them badly may mean disaster. To solve them well requires adequate knowledge and especially clear thinking. Bias and prejudice are liabilities or handicaps that we cannot well afford and hence should try by all means to reduce. If, in a republic, we are to have our affairs well handled, we must rear millions of capable unbiased persons to make those varied problems their life concerns. That, it seems to me, demands the scientific attitude of mind and an efficient system of education expressly devised for that purpose; for it is not something which we gain by inheritance or in the common experiences of life. . . . .

Having harped at length on the importance of science, I must ask you not to misunderstand me as implying that science is all we need. It is no panacea for our troubles. Indeed, if we were exclusively scientific, we should not be human at all. There are other things that are also necessary—love, art, imagination, intuition, loyalty, industry, and many others. It is my purpose merely to emphasize the opinion that science is one of the most indispensable factors in civilization. We must become more scientific and especially more widely scientific. . . . .

At this point it may be asked what results we can fairly expect from such improvements in our educational arrangements in the next decade or century. The experienced scientist will understand that sound improvement in human affairs will come only by evolution and after cautious experiments on a small scale rather than by sudden revolutionary changes on a large scale.

One of our greatest dangers lies in the impatience of many people to gain great results quickly. This is natural enough, in view of the brevity of our individual lives. But it is inconsistent with the principles which govern all life. We are a part of nature and, however much we may seem to influence natural processes, it can hardly be denied that we are in fact and on the longer view controlled by nature. Whether we like it or not, slow evolution is nature's way. And so we can scarcely hope to elaborate some theoretical new scheme of social or economic organization, put it into practice on a national or world-wide scale in a few years, and have any reasonable prospect of success. Hidden faults and weaknesses are likely to cause failure, and that in turn may exhaust for decades even the healthy impulse toward improvement. The fascination that these schemes have for our youth doubtless has a complex cause, but it may well be due in part to the faulty character of our current education, which has not given them the advantages of the scientific viewpoint. Again, as Daly said, they should learn to "think to scale.". . . .

There are many who expect that man will make continuous progress toward higher and better things, becoming in the course of time so much wiser, more sensible, and reasonable that the world's life will be vastly more happy than it has ever been in the past. War, sickness, and poverty would then be abolished. Cruelty, hate, and injustice would become obsolete, and we should be living in a sort of Golden Age the like of which we have never even approached. That is a beautiful vision to contemplate, especially in these dark times.



Courtesy The Hydraulic Press Manufacturing Company

MEN AND MACHINES AGAINST TIME

(700,000-lb hydraulic press now being put in production service in England for forming fuselage parts of bombers. This 5000-ton press has a rubber pad (168 in. × 50 in.) recessed into the bottom of the press platen which takes the place of upper dies. Inexpensive lower dies, mounted on the press bolster plate, are made from masonite and reinforced with steel at their cutting edges. This method of cutting and forming metal aircraft parts is known as the "Guerin" process.)

The lessons of historical paleontology may throw a beam of light ahead on this speculation—for of course it is no more than that. As we look back over the history of man we find evidence of great progress since the time of the primitive caveman, who made crude stone implements but lived in isolated families competing with the wild beasts of the day for such food as could be found or seized. He was indeed only one of the beasts, and it is hard to point out more than a few respects in which he was superior to them. Did the early Stone Age men gradually develop, by slow practice and learning, into modern man? We do not know, but there is little reason to suppose so. All that we know today of human paleontology indicates that what we loosely refer to as man comprised a group of at least five and probably eight or more distinct animal species which are generally grouped by zoologists in several genera. These may have originated in various parts of the world, each lived many tens of thousands of years, but eventually with one exception all became extinct. At certain times two or more such species may have coexisted, although probably in different regions. Perhaps they eventually killed off each other, just as the white race in historic times has exterminated the Tasmanians and certain other primitive tribes. But today only one species survives, and he has apparently had the field all to himself since the middle of the last glacial epoch, or about thirty to fifty thousand years ago, according to current estimates. Each of these species appears to have been as distinct from the others as species and genera of animals usually are.

How these various species of men came into existence is unknown and may well remain so. But there is nothing to suggest that their origin differed in any way from that of the other animals. To suppose that it did would be gratuitous speculation. Indeed, had it not been for the achievements of the latest of these species, the *Hominidae* would never have been entitled to special notice as anything more than somewhat peculiar mammals.

From biological friends whom I have consulted, I learn that they are not yet agreed upon the question of how a new species originates. In fact, there is some difference of opinion as to just what constitutes a species, as contrasted with a race, a variety, or even a genus. While waiting for the biologists to work out these problems, we may use the term *species* a bit vaguely in its current meaning, and we may tentatively adopt the now preponderant view that new species originate not by gradual imperceptible changes, but by sudden mutations, either extensive enough to produce a distinct species at once or occurring in series which eventually culminate in full specific status.

However any new species actually originated, its parental species doubtless continued to exist for a time without much change. The new kind expanded in numbers and, if more effective, eventually overran and exterminated the older one. It then went on living without important physical change until it was in turn crowded out by more efficient animals or succumbed to other adverse factors in its environment.

Have we any reason to suppose that *Homo sapiens* is not subject to the same process or that his fate will not be similar? He differed from earlier species of men very slightly in physical form and structure. His achievements and the shapes of his crania suggest that he possessed, from the outset, not only a larger but probably also a distinctly better brain, which has enabled him to learn more extensively, to devise complicated languages, and eventually to develop what we now call civilization. This progress seems to have gone forward on a steadily rising curve. For perhaps 20,000 years *Homo sapiens* was only a savage, a wandering hunter. In the next 5000 years or more he advanced locally to the status of a shepherd and even a village farmer. In another 3000 years he learned to extract and use metals, form cities or states and even nations, and become skillful in many of the finer arts. Accelerated advance in the next 1000 years led to books, commerce, literature, and philosophy. The last century or two has witnessed a rapidity of material progress in communication and far-flung organization that exceeds anything previously known; and with it has come much growth in ideas and in the complexity of economic and social arrangements.

Are we justified in assuming from the contemplation of that curve that it will continue to rise indefinitely, and at a similar rate? Is there in all geologic or human history any precedent for that? Other animal species of the past have followed career curves that involved a rise, culmination, and decline. We have seen the same law controlling the nations and even races of humanity. Will our own species also reach its climax and then deteriorate? And if that happens, how and when will it occur? As yet we have but little basis for answers to such questions.

In contrast with his progress in ways and ideas, *Homo sapiens* seems to have undergone only slight physical changes, even in the estimated 30,000 years of which some records have come down to us. Anatomically there seems to be no evidence whatever of any progress—no increase in cranial capacity, probably no appreciable change in brain anatomy. In the last 3000 years, for which some evidence is available, there is no sign of any improvement in native intelligence. Man's actions are still governed more largely by his emotions and subconscious mental elements than by his intellect. His savage instincts, that we like to think began to be conquered thousands of years ago, are still present beneath the surface and reappear at unexpected intervals even in civilized man. Among the more backward modern races of humanity they have scarcely changed.

In short our surviving species of *Homo*, being one of the mammals, is probably as definitely limited in his possibilities as are the other species of that class. Just as we do not expect a dog to learn algebra, although he can learn to open a door, so we probably ought not to expect more from present-day man than his brain is capable of attaining. As Hawkins, the English paleontologist, sees it: "Our mental capacity is a specific character." If this is the truth of the matter, it may be over-optimistic to expect our own species to rise far above his present stage of mentality. Notable improvement along lines already established, and a raising of the other two thirds of the Earth's population to or above the level of the present civilized minority, may well take place over the centuries and thousands of years yet remaining in the expectable future life of this species. His contribution to biological progress will then have been made, and if history is to repeat itself, he will then be ready for conquest, if not extermination, by some other type of being—perhaps some new species of the *Hominidae* that has more innate capacity for progress. . . . .

It is of little consequence whether such a new species may have smaller teeth, a skin less hairy, or taller stature. The only way in which he is likely to outstrip *Homo sapiens* effectively is in the quality of his brain. Will he be able to absorb knowledge more rapidly and remember it better? Will his imagination be keener, will he reason out his problems more effectively; and, above all, will his life and conduct be controlled by his intellect rather than by his feelings? If so, he may be able to take knowledge in larger doses, profit more by the stored-up experience of others, instead of merely his own, and by the lessons of history. He should be far more educable than any earlier species in the family.

It may be objected that these speculations are hardly optimistic, that they do not present a hopeful picture, and that they do not necessarily envisage continued progress toward a far higher and better human world. To this I must reply that a scientist is under no obligation to be an optimist. His only concern must be to approach nearer to the truth. If the truth offers hope, we may all rejoice. If it fails to do so, we are not thereby justified in denying or even ignoring it. As King Solomon long ago advised, let us get understanding, and by so doing we may reach a serenity of outlook that will fit us better to play a worthy, even though minor, part in the great drama of human evolution.

Butter and Guns

THE SCIENTIFIC MONTHLY

THE group of papers on vegetable oils presented under the auspices of the Process Industries Division of The American Society of Mechanical Engineers at the 1941 Spring Meeting of the Society, Atlanta, Ga., March 31–April 3, directed attention to the mechanical aspects of vegetable-oil processing, a field in which the Society is participating in its support of the cottonseed-oil research at the University of Tennessee. Several reports of the progress of this research have appeared in this Journal.

In the May, 1941, issue of *The Scientific Monthly*, Alfred W. Booth, of the department of geology and geography, University of Illinois, considers another aspect of our interests in vegetable oils in an article entitled, "Can the United States Have Butter and Guns?" There are few people who realize, according to the author, that our country would be faced with an acute

problem if our imports of vegetable oils and fats were cut off.

The annual consumption of animal and vegetable oils and fats in the United States, he says, is over 71 lb per capita, a figure which far outstrips that of any other large nation. In view of this, animal and vegetable oils and fats must be considered as we plan for national defense. Since animal oils and fats in this country are normally adequate, the author stresses problems associated with vegetable oils and fats.

Figs. 1 and 2 are presented to show the relative quantities of primary vegetable oils and fats consumed in factories in the

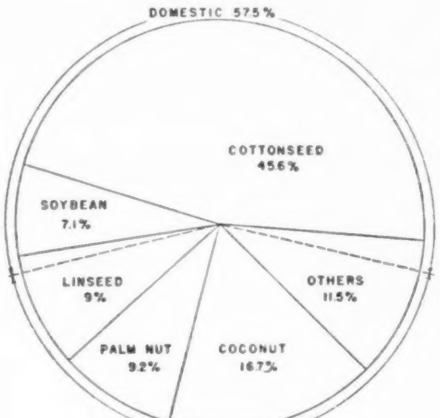


FIG. 1 PRIMARY OILS AND FATS CONSUMED IN U. S. FACTORIES, 1938

United States and relative quantities of the oil and fat products produced from them.

Of the three and one half billion pounds of vegetable oils and fats consumed in our factories in 1938, almost one half, or about one and one half billion pounds, was imported. These oils and fats come to us principally from the Philippine Islands, the Netherland East Indies, China, West Africa, Argentina, Brazil, and Japan. The fact that we are now so dependent upon outside sources for vegetable oils and fats must be considered in charting the course of American foreign diplomacy and agricultural economy.

The question finally arises: How would this nation fare if all these sources of vegetable oils and fats were cut off from us by war or blockade? The immediate result, especially if this severance were sudden, would be an acute and dangerous shortage for an indeterminate period. The ultimate result would depend upon our ability to make shifts in our agricultural economy, to develop substitutes, and to make technological changes. All this presupposes that we would not be content to lower our living standards to those which exist on Continental Europe.

Let us first consider our ability to increase our domestic production of vegetable oils and fats. Physical conditions, chiefly climatic, make it impossible for us to grow the coconut, oil, and babassu palms, which, together, now supply us with about one fourth of all our vegetable oils and fats. All other significant oil-producing plants, such as cotton, flax, tung, soybean, corn, and castor bean, can be raised successfully in this country. Despite this, we now import vegetable oils and fats derived from all except one of the plants just listed. Thus, any campaign for self-sufficiency would, perforce, have two objectives: First, to become independent of outside sources for the oils and fats of the plants we can raise; and, second, by utilizing native plants, to balance the deficit which would exist because we cannot grow oil-producing palm trees.

The leading native source of vegetable oil is cottonseed. Better methods of expression and complete use of all our seed would easily make up for the small amount of cottonseed oil which is imported. However, under existing cotton prices, a great extension of acreage, sufficient to make up our deficit, seems improbable. It might be stated at this point that a variety of cotton which produces little lint and a seed which has a high oil content has already been developed. However, to make this type of plant profitable, oil prices would have to rise considerably.

Next on the list of oil-producing plants which are grown in the United States is flax, whose seed (linseed) is the leading source of drying oil. At present we supply about one third of our need. Most of this comes from the grainlands of the Dakotas. In view of our large annual wheat surplus, it would seem that the simplest solution to the problem would be to turn wheat acreage over to flax. However, flax is a difficult plant to cultivate and harvest, and, in addition, is much more subject to losses through vagaries of weather, weed growth, insect pests, and blight than is wheat, so that even now, in spite of high protective tariffs, it is not a popular crop. Perhaps some form of government crop insurance to make it a less speculative crop would encourage increased production. Some small subsidization might also be necessary. If these measures were instituted, flax acreage might be increased to about the necessary 4,000,000 and self-sufficiency be attained. The recent development of strains of flax producing good oil seed and fiber suitable for linen (also a need in this country) will probably be an added incentive toward more flax production.

A second source of drying oil is the tung tree. The United States imports 85 per cent of its need of this important paint, lacquer, and waterproofing material from China. Tung oil also enters into the manufacture of such products as linoleum, oil cloth, brake lining, and inks. Since the Chinese supply was uncertain even in prewar years, tung-tree orchards were started in our Far South (southern Mississippi, Alabama, Georgia, and

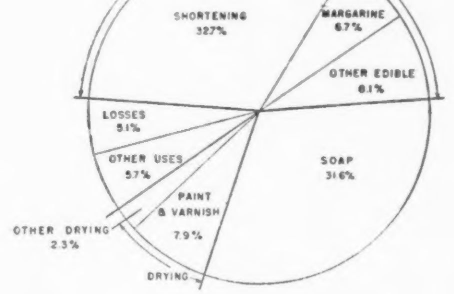


FIG. 2 OILS AND FATS PRODUCTS PRODUCED IN U. S. FACTORIES, 1938

northern Florida) about forty years ago. Today, the lessons of production having been learned, the United States is well on the road to self-sufficiency, a goal which might well be reached in the next ten or fifteen years if the present rate of increase is maintained. For the time being, however, we are still dependent upon China.

Since both drying and edible oil can be obtained from the soybean, that source of oil has unique value. So great are the potentialities of the United States for soybean production that we already supply all our own soybean-oil needs with ease. Large areas in the Corn Belt are almost ideal for its production. The great surplus of corn in recent years would seem to indicate that this cornland could easily, and even more profitably, be turned to the soybean, which also has the advantage of being a leguminous crop. Another large region of the United States

which is suitable for soybean production is the South, where it is now grown mainly as a forage crop. The 16-million-acre reduction in cotton acreage in this country in recent years has certainly made land available for raising soybeans. If soybean production could be tripled, at least one third of our deficit of vegetable oils and fats could be overcome.

Two other crops which might be produced in increasing amounts in our South are the peanut and castor bean. Peanut oil is an excellent edible oil and could well take the place of either the olive or cottonseed as a source of salad oils and in margarine production. By increasing our acreage only one fourth we could become self-sufficient. Even a twofold or threefold acreage increase should not be difficult. Castor-bean oil is an important source of lubricants, particularly for use in aviation, and thus has special strategic importance. Our need could easily be supplied by domestic production.

The case of corn as a source of vegetable oil is a puzzling one. This country has always produced a tremendous quantity of corn, very little of which, however, is utilized as a source of oil. During the first World War corn oil entered the market to make up for the deficiency in fats and oils which existed at that time. Admittedly, this oil was for a while inferior to other types, but was very soon brought to a desirable quality standard. Yet after the war, it almost dropped out of sight in spite of extensive advertising campaigns. Perhaps another effort to educate the American housewife to its desirability would be the most effective wedge toward its increased use. Corn oil, along with soybean and peanut oil, might be the answer to the problem of making this country independent in its supply of edible oils and fats.

It thus appears that, if, in this country, we expect to have and to continue to have our guns along with our butter, we must be prepared for certain eventualities. At present, the most serious threat upon our supplies of vegetable oils and fats lies in possible Japanese aggression in the Far East. This threat would be especially serious if the Philippines were lost, because it would certainly be followed by a period of acute shortage and technological change. If we did not prevent such an eventuality, our best opportunity to prepare for its consequences would lie in the development of South American sources, and some changes in domestic production. Of course, even the present or projected South American supply could be cut off, for example, by political unrest or by German economic penetration. Unless we are prepared to go through a rather painful readjustment period of from five to ten years, we must either be ready to prevent certain eventualities or must begin to prepare now for complete national self-sufficiency in vegetable oils and fats.

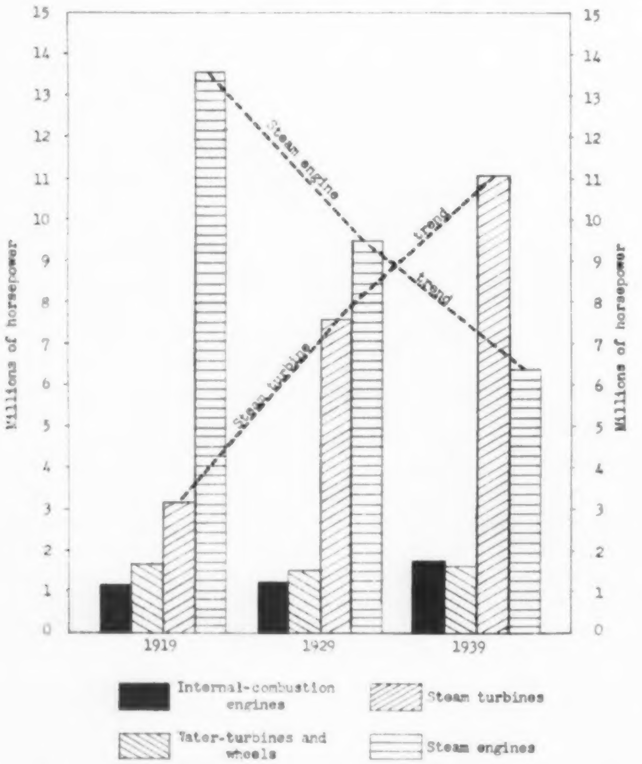


FIG. 3 STEAM TURBINES RAPIDLY DISPLACING STEAM ENGINES IN AMERICAN MANUFACTURING PLANTS—PRIME MOVERS IN MANUFACTURING PLANTS FOR CENSUS YEARS 1939, 1929, AND 1919

Power Census—1939

BUREAU OF CENSUS, U. S. DEPARTMENT OF COMMERCE

A PRELIMINARY report of the U. S. Department of Commerce, Bureau of the Census, of the Census of Manufacturers, 1939, released on April 6, 1941, indicates that the factories

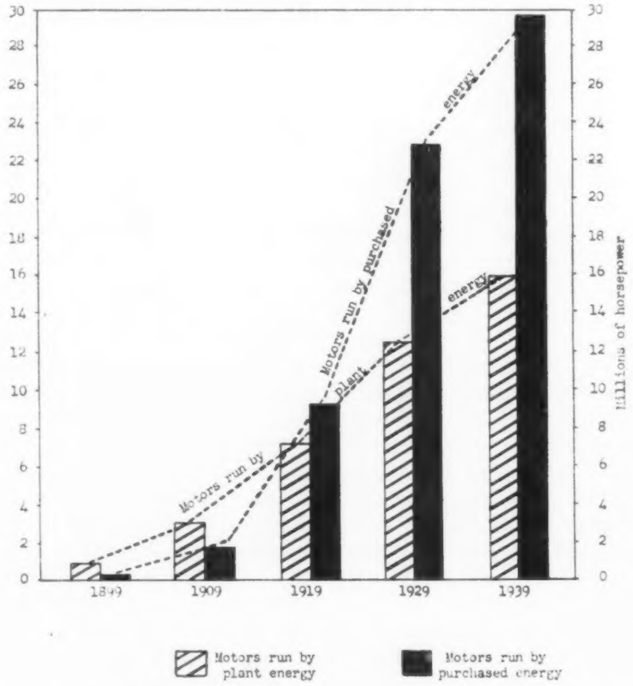


FIG. 4 TREND OF ELECTRIC MOTORS RUN BY PURCHASED ENERGY AND ENERGY GENERATED IN MANUFACTURING PLANTS, 1899–1939

of the United States required a total of 51,154,523 hp in 1939. In that year the census figures show that 181,000 used power as compared with 193,969 in the boom period of 1929, the year of the last census. There were 183,277 factories in 1939 and 210,959 in 1929.

The power-generating equipment in plants having their own prime movers amounted to 21,266,557 hp, and the plants driven by purchased energy had motor capacity for making use of 29,887,966 hp.

The gain of 1,111,160 hp in generating equipment in the plants which produced their own energy amounted to 5.5 per cent in ten years while the gain in installed motors in those plants which buy energy was 7,112,302 hp, or an increase of 31.2 per cent in ten years.

The greatest gain in prime-mover installation was reported for steam turbines which increased by 3,564,826 hp, or 46.1 per cent. Steam-engine installations in these establishments decreased by 3,066,675 hp, or 31.9 per cent. Internal-combustion engines increased by 568,958 hp, or 46.1 per cent, and hydraulic turbines and water wheels showed only a slight increase of 44,051 hp, or 2.9 per cent. Factories having their own power plants reported as ordinarily idle 1,996,753 hp, indicating 19,269,804 hp actively in use. The factories which had their own power plants reported that they used 65.6 per cent of this power to drive electric generators.

The census report on power indicates a continued trend toward further electrification of industry. Installed electric motors showed a gain of 10,814,584 hp, or 30.8 per cent.

The kilowatt rating of electric generators in these establishments totaled 9,674,934, as against 7,793,875 kw in 1929. Seventy per cent of these generators, as measured in kilowatt ratings, were driven by steam turbines.

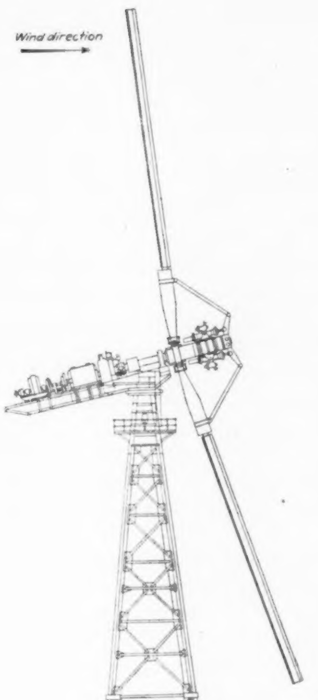
The factories purchasing energy used a total of 45,040,866,703 kwhr during 1939, compared with 37,393,833,046 in 1929.

Smith-Putnam Wind Turbine

VARIOUS SOURCES

IN process of erection on Grandpa's Knob in the Green Mountains about 10 miles west of Rutland, Vt., is a test-unit installation of the Smith-Putnam wind turbine, designed and manufactured by the S. Morgan Smith Company, which will drive a 1000-kw electric generator.

The site was selected after elaborate meteorological investigation as one of a number of excellent locations available. It is expected to provide wind sufficiently steady for an availability factor greater than that for stored water as used in New England or at most other hydroelectric sites. Investigations indicate that a 30-mile wind will operate the turbine up to rated capacity and that this wind velocity will prevail at Grandpa's Knob between 4000 and 5000 hours during the year.



Courtesy Power

FIG. 5 SMITH-PUTNAM WIND TURBINE

Mounted on the top of a structural-steel tower, the wind turbine, 175 ft from tip to tip, has 65-ft blades that look like airplane wings. Fig. 5 is a sketch of the general arrangement, Fig. 6 is a shop photograph of the hub post to which the blades are attached, Fig. 7 shows one of the blades which is 65 ft long and 12 ft wide, and Fig. 8 shows the Vermont location with the tower in process of construction in the background.

The test unit now being erected has a wing spread of 175 ft and is rated at 1000 kw. It will be realized that with such a large diameter the turbine must necessarily revolve at low rotative speed in order to keep the peripheral speed within a reasonable limit. On this unit the tip of the blades will travel at approximately 180 mph and the turbine shaft speed is stepped up through two pairs of speed-increaser gears to drive the generator at 600 rpm. The entire rotating mechanism is mounted on a structural-steel tower 120 ft high. The spread of the tower at the base is 40 ft and the batter such that the tower cap is reduced to about 6 ft diameter at the top. With the exception of the blades, the entire mechanism mounted on the tower will be enclosed in a streamlined shell, not indicated in Fig. 5. The wind turbine has four principal motions:

1 *Rotation*. Under normal operating conditions the blades and consequently the turbine and generator shafts are rotated by the wind at a practically constant speed under control of a speed-sensitive governor, thus producing power at the generator.

2 *Pitching*. In order to maintain constant speed under varying wind velocities it is necessary to pitch both blades alike about their own centers of rotation. This is done through a common actuating system by means of oil pressure.

3 *Yawing*. The entire mechanism mounted on the top of the tower, including the generator, shafts, and blades, will be rotated about a vertical pintle shaft in bearings mounted in the tower cap to keep the turbine axis closely parallel to the wind direction. The blades will always

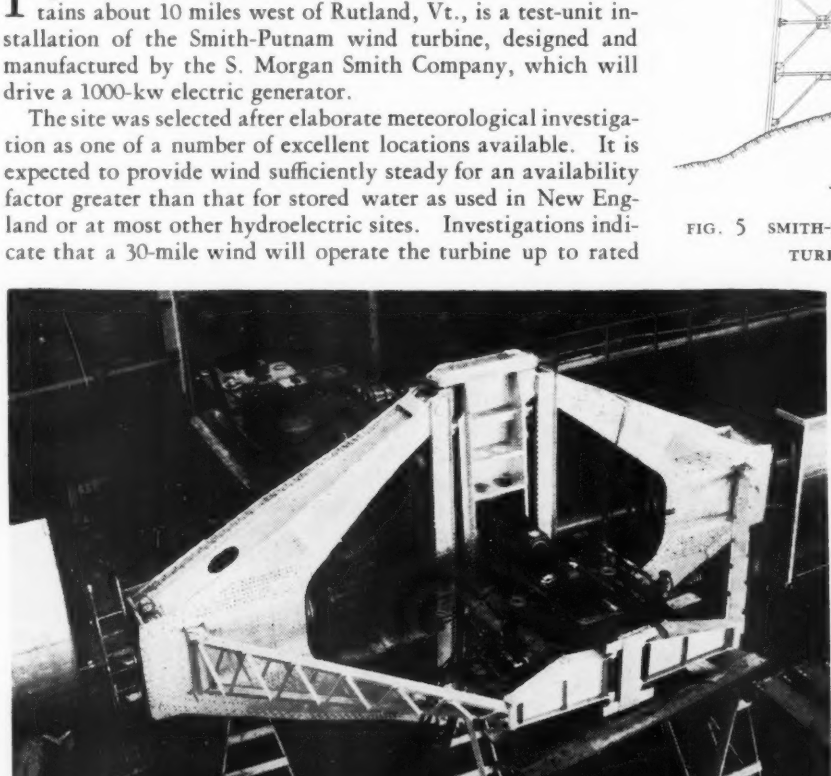


FIG. 6 HUB POST OF SMITH-PUTNAM WIND TURBINE

(Inner ends of the two blades are visible at each side of the photograph, within which are the two *A*-frames with the hub post between them. Torque tubes for pitching or feathering the blades extend from the center of the hub post through the *A*-frames to the blades. The gearbox is visible behind the *A*-frame on the left. Behind the gearbox the generator will be located. Structural members extending from the *A*-frames to a point on the tailpiece downwind of the hub post operate levers which in turn operate a shaft and piston through coning damping cylinders to damp the speed of coning when sudden gusts hit the blades.)

be kept downwind of the tower and the generator and turbine-shaft axis is on an angle with the horizontal, the blade end being high, so that there is no danger of the tips of the blades striking the tower legs. The yawing about the vertical axis is accomplished not by the action of the wind directly upon the parts aloft, but by a hydraulic motor, the flow of oil to which is controlled by a weather vane.

4 *Coning*. Each blade is free to pivot independently on pins attached to the blade hub. The coning motion is at right angles to the plane of rotation; that is, up and downwind, and the purpose is to avoid the extremely high stresses which would otherwise obtain due to severe gusts of wind. The position of the blades in respect to coning is the resultant of gravitational, aerodynamic, and centrifugal forces.

The scheme of operation with respect to wind velocities is, in simplified form, as follows:

Assuming at the start a dead calm and wind gradually increasing, when sufficient wind velocity is reached to rotate the turbine at about 5 to 10 per cent of rated speed, the switchgear will automatically cause the blades to be placed at the angle of maximum power. As the wind velocity still further increases, the turbine will gain in rotational speed until rated speed is reached at about a 15-mph wind, when the switchgear will automatically synchronize the unit with the electrical system to which it is connected and cause the main breaker to be thrown in. Any increase in wind velocity now increases the output of the generator; and the turbine blades will remain at the maximum power angle until the wind velocity has increased to about 30 mph, at which velocity the generator would be fully loaded.

As the wind further increases in velocity, it is necessary to increase the pitch of the blades in order to maintain speed and still keep within the capacity of the generator. A load-limiting device connected in the generator outgoing leads prevents overload. At wind velocities in excess of 30 mph the turbine continues to generate the rated output of the generator with gradually increased blade pitch.

The entire operation of the machine will be automatic and the turn of a single switch will normally start or stop the unit. Great care has been taken with this initial test unit to provide all conceivable protective devices which will automatically and safely bring the unit to rest by feathering the blades in the event of any known electrical, mechanical, or aerodynamic trouble. It is expected that many of the complicated devices now made necessary by the experimental nature of the unit may be eliminated on future installations on the basis of the experience gained this coming summer on the test unit.

The General Electric Company, American Bridge Company, Budd Manufacturing Company, Wellman Engineering Company, and a number of consulting engineers and technicians, have collaborated with the S. Morgan Smith Co., engineers, on this project. Dr. Theodor von Kármán, member A.S.M.E., director of the Guggenheim Aeronautical Laboratory at California Institute of Technology, is aerodynamic consultant. Dr. J. B. Wilbur of the Massachusetts Institute of Technology is chief engineer, and Palmer C. Putnam of Boston, designer of the wind turbine, is the project engineer. The wind turbine now being installed on Grandpa's Knob was built by the S. Morgan Smith Company of York, Pa.

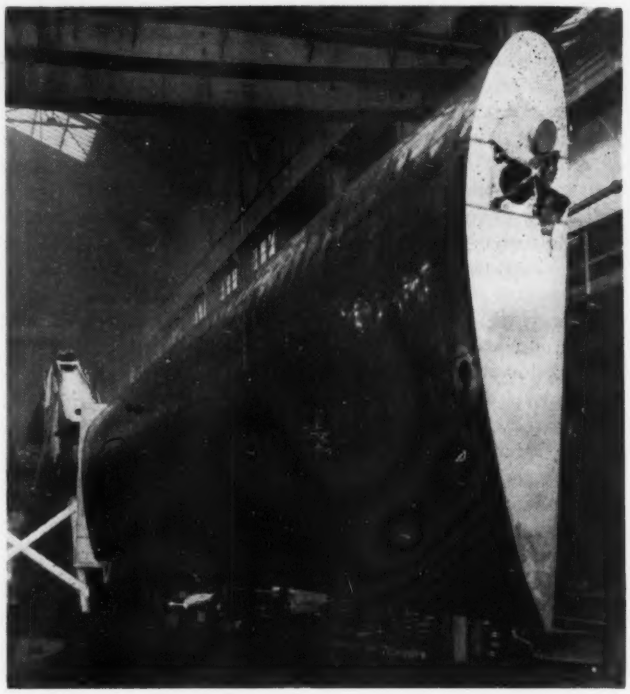


FIG. 7 A 65-FT BLADE OF THE SMITH-PUTNAM WIND TURBINE

Moving of the larger pieces of equipment to the site has proved to be quite a transportation problem. All the heavy equipment has, however, been delivered and the erection will be complete on or about June first.

Material on which the foregoing is based was provided by G. K. Sauerwein, chairman, Boston Section, The American Society of Mechanical Engineers, and George A. Jessop, of the S. Morgan Smith Company.

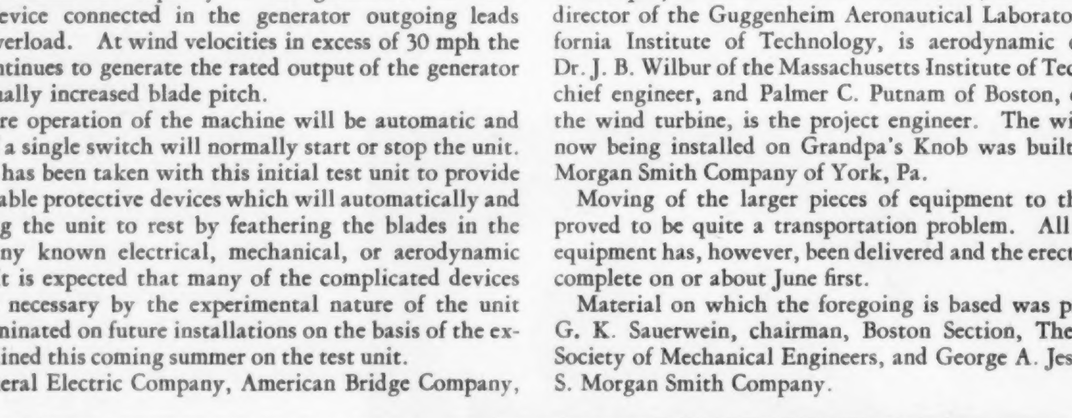


FIG. 8 SITE OF THE SMITH-PUTNAM 1000-KW WIND TURBINE AT GRANDPA'S KNOB, VT., SHOWING TOWER IN PROCESS OF ERECTION IN THE BACKGROUND AND ONE OF THE 65-FT BLADES IN THE FOREGROUND

COMMENTS ON PAPERS

Including Letters From Readers on Miscellaneous Subjects

National-Defense Planning

To the Editor:

The letter entitled "National-Defense Planning," from Mr. Gormly,[1] raises two very important questions. First, should an engineering investigating committee examine the defense needs of the country with a view to saving the country from internal bankruptcy as well as from external aggression? This would seem to be an excellent idea, regardless of whether or not one agrees with Mr. Gormly's analysis of the outcome of such an investigation. It is an excellent idea because engineering committees are much freer from hysteria than most political groups are, and also because internal bankruptcy could very easily result in internal revolution and the loss of democracy which every engineer holds dear. No thoughtful engineer can fail to realize that our present defense bill of some thirty billions has raised the national debt far above the heretofore accepted "dangerous" limit.

Such an investigation might be carried out by the Society as a purely advisory measure. It should deal primarily with the economics of national defense, leaving the purely military analyses to government departments obviously well-equipped to handle all such matters. Results could be published and furnished to members of the legislative and executive branches of the government with the thought that they would be welcome to use the information for whatever value they might consider it to have.

The second question raised by Mr. Gormly relates to what course of action engineers might take if their advice were refused. Specifically, he suggests "engineers may live up to their own moral obligations by refusing to participate in 'total defense.'" How far individual engineers might refuse to go in "bankrupting" a country against the wishes of the very government of that country, seems especially debatable in the case of the engineer. In a democracy it is the duty of the ordinary citizen to express his own considered opinion and to have full freedom of personal action within the law. The engineer, however, has also a code of professional ethics the ordinary citizen does not have. His situation may be likened to that of a medical doctor who personally may feel it unmoral to save the life of a newborn crippled child yet who is ethically bound to see that it lives.

How far should the new concept of social responsibility of the engineer be carried in the case of say the designer of long-distance bombing planes? Does such a designer, whose powerful weapon of offensive destruction is demanded by society, have the right to refuse society such service if, in his own conscience, he deems his social responsibilities otherwise? So far it appears European engineers have answered this question in the negative, if there is any significance to the professional classification of refugees arriving in this country from Nazi-dominated nations there. Among such groups are to be found those of doctors, lawyers, writers, musicians, etc., of the very highest caliber. Engineers appear to be by far the smallest group. This might mean that either engineers are lacking in social responsibility or that they are more susceptible to totalitarian propaganda than are other professional people. Let us hope, however, that neither of these reasons is the case.

O. F. Zahn, Jr.[2]

[1] Mechanical Engineering, April, 1941, pp. 305–306.

[2] Martinez, Calif. Jun. A.S.M.E.

Unionization of Engineers

To the Editor:

Since the question of the unionization of engineers was discussed by various correspondents in the "Comments" column of Mechanical Engineering this writer has had many occasions to discuss and to debate the matter with a number of A.S.M.E. members and engineers of other lines, getting thereby a few new angles on the problem. Conditions in industry, too, developed in general in a new direction as a result of defense requirements, all of which make the following additional comments appear to be timely.

One of the most frequent arguments against the unionization of engineers met with is the claim that unions tend to increase the costs of production, while it is the business of the engineer to reduce the same. This claim may refer to various points. The first one is the question of wages, the primary objective of union activities. This I covered in my previous letter on the subject[3] when I pointed out that due to the comparatively small export trade of this country (about 5 per cent of the total trade) the only real market for American production is America, and that unions are very important agencies bolstering the purchasing power of this market by demanding higher wages. Besides the wage question is not an engineering problem, it is a matter of bargaining, and of supply and demand on the labor market. The second point is the number of working hours per week. Unions try to cut down and keep down this figure in order to spread employment, and will do so as long as there will be unemployment. As to the latter, greater powers than engineering employees tried to eliminate it without any result, and so it would be unfair to expect an engineer not to join a union in the hope that he can do more for the elimination of unemployment and its consequences by staying out of the union.

The third point is a better utilization of labor by means of motion studies, improved organization, better tools and machines, and the other well-known methods. These are engineering problems, but they, too, interfere with the spreading of employment, consequently, even the most gifted, experienced, and zealous engineer will not be able to overcome the reluctance of the workers against these methods, whether he be a union member himself or not.

It must be remarked here that it cannot be said that trade unions are against efficiency in production as long as it is not against their interests. One good example to prove this was one of the conditions in a recently concluded collective labor contract in the ladies'-garment trade requiring that the employers operate their plants efficiently, to which the em-

[3] Mechanical Engineering, vol. 62, 1940, pp. 69–72.

ployers had to agree upon demand of the union. Another example is the Reuther plan by a leader of the Automobile Workers' Union proposing that plant capacities of automobile factories, idle during a great part of the year, shall be utilized for the manufacturing of small pursuit airplanes and other armaments. As to war conditions, the costs of living rising faster than salaries and wages, especially in nondefense industries, the protection of jobs for enlisted men, etc., are all arguments for unionization too well known to be repeated here. In addition to these, there are other points in the interest of defense to be considered.

In ordinary times production is conducted for profit, and the purpose of reducing costs is to increase profits. At present, however, production in many lines is conducted for defense, with profit —so we will hope—as a secondary consideration only. Naturally, it is very essential that production in these lines should continue smoothly. Unfortunately, in several instances this is not the case, for which both parties try to fix the blame on each other, partly during the litigation, partly in the press. For the latter purpose all labor can use is its own press, while the employers have the general daily press at their disposal, with the result that the general public gets one-sided information and forms its opinion accordingly. Whatever the truth of the matter, the question in the present connection is whether the engineer could secure a smoother flow of operation and production and obtain better cooperation from the workingmen under him, if he, too, were a union member. This writer witnessed a case abroad in which a foreman, a strong union man himself, got the best cooperation from the men under him by giving them the worst imaginable scolding whenever they deserved it, but never omitted to address the guilty ones as "Mate," which was the usual, official way of addressing fellow union members in those parts. By this he made his subordinates feel that he wanted good and efficient work from them as a matter of keeping up self-respect and of maintaining the good reputation of the union and the trade, and not in order to squeeze out more profit for the boss.

It is highly probable that an engineer as a union member likewise could have a very beneficial influence upon his subordinates. As things stand now, the unionized worker, even if he has a personal esteem toward some individual engineer, looks with contempt and scorn at the nonunionized engineer and white-collar worker in general, whom he rightly considers to be an employee like himself, even if of a different trade, only with not enough backbone and intelligence to get organized into a union. This unsound relation between engineer and worker could be changed for a much better one if the former, too, would become a union member; in fact it is highly probable that many of the present labor troubles could have been avoided through the more reasonable, cool-blooded, and intelligent active cooperation of union-member engineers.

Finally, another result of conversations with fellow members of the A.S.M.E. was the confirmation of an old conviction and contention of this writer that there are many more members in favor of the unionization than it would appear by the contributions to MECHANICAL ENGINEERING, only they are under the terror of jeopardizing their connections by coming out into the open with their opinions. This is true about individuals as well as about whole groups. A good example is one of our greatest industrial plants in the Middle West. The same employs enough engineers to form a small society or club of their own. The secretary of this club, not an engineer, sent word indirectly to this writer that the contributions concerning the unionization in MECHANICAL ENGINEERING were subjects of lively discussions, with everybody in favor of the union, and yet there was not a single letter from that group to our journal. It is true that our editor announced on the editorial page that contributions on unionization will be published with the signatures omitted, provided the writing member signs his name for identification by the editor only, but requests that his name shall not be published. Still, some members confided it to this writer that they would not dare to send in contributions even under this condition.

All this proves that the only way to obtain a sincere expression of the real opinions of the members concerning the question of unionization is by means of a secret vote, as urged in my previous letter. After all, this country, the A.S.M.E., and every other democratic institution is governed by means of the secret ballot. Accordingly, this is submitted with the suggestion to arrange for a secret vote on this vital question, as open correspondence will not reveal the real feelings of the great majority of the members.

ANDREW A. BATO.[4]

[4] East Orange, N. J. Mem. A.S.M.E.

H. M. Hobart

TO THE EDITOR:

After some forty-eight years of active participation in the development of the electrical industry, H. M. Hobart, Member A.S.M.E. since 1915, has just retired from the service of the General Electric Company to devote his attention to the pursuit of private consulting work. This seems a fitting occasion to enumerate a few of the activities that come to the mind of an observer on the side lines as projects that Mr. Hobart has promoted vigorously at some time or another. They are merely glimpses of a much fuller record which Mr. Hobart is being urged to cover by an autobiography which would be both an interesting and historically valuable account. This fuller record would extend back to the early 1890's when Mr. Hobart, upon his graduation from M.I.T., first went to work on assignments from Prof. Elihu Thomson, E. W. Rice, and others among the founders of the present General Electric Company. The records of those days are not available for the present review which merely is a broad reference to the years from 1911 on. For several years prior to 1911 Mr. Hobart was engaged as a consulting engineer in London, England, to which destination he originally went in 1896 on behalf of the General Electric Company to cover special assignments with its affiliated companies. In that connection Mr. Hobart also spent several years in Germany with the G.E. associates there.

Upon the return to Schenectady Mr. Hobart made an extensive study of induction-motor designs with the object of making recommendations for decreasing the size, weight, and cost for given ratings of this type of machine. The findings of this investigation were that the rating for a given air-gap diameter could be approximately doubled by lengthening the machines by 10 to 20 per cent, by using more copper and less iron, and by employing improved ventilating schemes. As a by-product of this work Mr. Hobart discovered the deep-slot effect which has been generally used in the industry since.

Another investigation made at about the same time covered the use of bare enameled wire in transformer windings where cotton coverings had formerly been considered necessary. By adopting this practice in small transformers where the voltage between turns is of fractional magnitude, the size of transformers could be reduced and the core or copper losses could be lowered.

At a relatively early date Mr. Hobart was also an ardent advocate of increased

temperature rises in electrical apparatus, with resultant gains in efficiency, and of higher speeds of the magnitudes that have been adopted only in the last few years.

The benefits of transposed conductors were early recognized by Mr. Hobart who sought to promote this design innovation for use in both turbine generators and transformers a decade or more before American design practice saw their adoption.

After becoming acquainted with the European advances made in mercury-vapor rectifiers about 1919, Mr. Hobart zealously worked for their introduction in the United States but it was practically five years later that this type of apparatus gained recognition here as a practical power-plant unit.

The use of series capacitors represents another item that forms the subject of enthusiastic reports by Mr. Hobart in the early 1920's.

Mr. Hobart became interested in electric welding about 1917 after having seen how extensively the British had begun to use this new art in their shipbuilding program for the World War emergencies. From that time on Mr. Hobart has successively put earnest effort back of covered electrodes, increased ampere capacity, adoption of alternating current, aging tests as a tool in the advancement of welding, and the selection of proper steels for best weldability. In recent years as chairman of the Fundamental Research Division of the Engineering Foundation's Welding Committee, Mr. Hobart has fostered innumerable projects carried out by more than one hundred researchers throughout the United States.

There are a good many other activities that have appeared on Mr. Hobart's calendar in the last 20–30 years, and among these apparatus standardization holds a prominent place. With exceptional vigor and zeal Mr. Hobart took an active part, for a long period of years, in the development of international electrical standards through the work of the International Electrotechnical Commission. His contributions greatly advanced this field and have had a continuing influence on accomplishments. Innumerable technical papers and the many volumes of engineering books that owe their existence to the authorship of Mr. Hobart are all proofs of a most varied and active career.

Great enthusiasm for new and better things has distinguished Mr. Hobart's career from the earliest days. This characteristic, together with his outspoken convictions that the electrical industry has barely begun to develop its opportunities, make Mr. Hobart's work an inspiration to everyone who has contact with him, and especially young engineers have benefited greatly from his visions in that respect.

With this side-glance review go the best wishes of the writer and of many others of Mr. Hobart's admirers for a long and pleasant continuation of the work so eagerly performed in the interest of the electrical industry.

JOHN HORN.[5]

[5] General Eleectric Company, Schenectady, N. Y.

Dimensional Analysis

TO THE EDITOR:

The handling of dimensional analysis by R. H. Sherlock and E. A. Stalker on page 148 of MECHANICAL ENGINEERING for February, 1941, illustrates a procedure that is likely to lead to error on the part of those not well-versed in the subject. A list of variables is set up in one of whose dimensions temperature (θ) appears. It is stated, "The term θ must be dropped, since none of the other variables contains the dimension of temperature and since there is no other variable having this dimension which might conceivably be added." This conclusion is unjustified. As the writers apparently realize, that none of the other variables listed contains θ means either that θ does not belong in the list or that the list of variables is incomplete. The alleged inconceivability of other variables being concerned that would involve θ merely means that the writers didn't happen to think of any.

The variables that belong there are rather cumbersome ones that link the temperature to the relevant mechanical properties of the fluids. Later on, the writers say that temperature may have an indirect effect on account of the change of volume accompanying the mixing of the stack gases with the surrounding air. Thus, they put temperature back into the situation. Now, if temperature has any influence, direct or indirect, it should be taken account of from the start, in some fashion or other.

The trouble is that temperature is here not a primary variable. The situation offered by the emergence of stack gases into the atmosphere is a mechanical problem. The primary variables are size and shape of stack, the velocities of the air and the gas, and the relevant mechanical properties of both fluids. These are density and viscosity. Inclusion of them in the original list of variables would carry with it the influence of temperature to the extent that temperature probably influences this situation. If the problem were one of issuance of gas from a tube into a liquid, the mechanical property *surface tension* would also have to be taken account of.

Dimensional analysis will be much more helpful if, in problems of fluid mechanics, the mechanical properties of the fluids are listed among the pertinent variables, rather than things like temperature.

ERNEST M. FERNALD.[6]

[6] Professor of Mechanical Engineering, Lafayette College, Easton, Pa. Mem. A.S.M.E.

Textile Waste

COMMENT BY E. J. CLEARY[7]

Stream pollution, discussed in this paper,[8] is not the sin alone of the textile industry. Other industries produce wastes which are discharged into streams. And since these wastes affect the very supplies which are used by textile mills, the broad aspects of industrial-waste disposal logically should hold a special appeal for mechanical engineers in the textile industry. Undoubtedly, they will be called upon more and more to participate in solving this major problem of industrial activity. All facts indicate that the stage is set for an era of widespread development in the application of treatment measures to the wastes which now pour into and defile our streams. Public opinion, pending national legislation, and cooperative effort on the part of industry itself are adding impetus to this movement for pollution abatement.

During the last decade, good progress has been made in providing facilities for the treatment of municipal sewage. But even if all domestic sewage were treated, this would only half solve the stream-pollution problem, because industrial wastes contribute equally as much pollution, if not more, than that which arises from domestic waste. For example, in New Jersey some 700,000 tons of solid wastes are deposited annually in waterways by industrial plants. It has been established by the New Jersey Agricultural Experiment Station that this is equivalent in bulk to the sewage from about 3,000,000 people, or three quarters of the population of the state.

[7] Associate Editor, *Engineering-News Record*, New York, N. Y.

[8] "The Treatment of Textile Wastes," by H. G. Gotaas, MECHANICAL ENGINEERING, November, 1940, pp. 805–808.

The job ahead is a big one. Estimates of the National Resources Committee, reported in 1939, indicate that it will cost more than $1,000,000,000 for disposal facilities to deal adequately with industrial wastes. Even if this staggering sum of money were now available, however, it could not be applied to greatest usefulness without further knowledge of, and development in, treatment methods applicable to various types of wastes. The dimensions of this job are as broad technically as they are wide financially.

This paper on textile-waste treatment specifically illustrates the magnitude and complexity of developing economical treatment methods for the wastes from a single industry. Furthermore, it should be recalled that this industry, through the Textile Foundation, has coordinated its efforts since 1932 in research and exchange of information concerning fundamental problems of waste treatment. Other industries might well be encouraged to follow this example and, with the aid of their associations, institute continuing studies of specific waste-disposal problems.

In this connection, the possibility of by-product recovery from waste-disposal processes may serve as an incentive in promoting installation of treatment measures. But the possibility of profit from such recovery must be viewed with caution. Perhaps the best that can be hoped for in most industries is the reclamation of certain materials which in part may help to defray the cost of treatment devices.

In conclusion, the writer would emphasize the author's remarks concerning the value of cooperative relationships between a city and its industries. Municipal sewage-treatment processes can accommodate certain types of waste, particularly where these wastes have been pretreated prior to discharge into sewers. In some cases, special facilities for handling industrial wastes could be incorporated in the design of municipal treatment plants. Of course, industry must assume its share of cost for these special services, but this is usually less than it would cost to provide separate and equivalent private disposal facilities.

COMMENT BY M. M. COHN[9]

The wastes of the textile industry are representative of the wastes of American industry which must be adequately treated if we are to prevent the pollution of our natural water courses. Similarly, the research and practical progress which the Textile Foundation has encouraged and developed is typical of the attitude which American industry must assume, and of the progress which is gradually being made in this important field of sanitation and conservation of natural resources. It is a pleasure to commend the author on his paper and to congratulate the Textile Foundation on nearly a decade of outstanding achievement in textile-waste research.

The many varieties of textile-processing wastes and the large quantity of materials to be handled have imposed trying conditions on this industry. That so much progress has been made should be encouraging to the other American industries which are faced with seemingly insurmountable waste problems, but which can certainly be solved by the same type of intelligent and intensive effort as that applied by the textile mills.

This paper is a ringing answer to those who feel that the enactment of national stream-pollution regulations is being delayed by the unwillingness of industry to undertake the treatment of their trade wastes. In addition to the textile industry, other industries have already demonstrated their willingness to expend major sums for this purpose.

Just as the Textile Foundation has shown the benefits of reduction in quantity of wastes and the recovery of by-products, so other industries will do likewise.

There are two avenues of approach to the problem of industrial-waste pollution; reduction in the amount of wastes by the industry itself and intelligent treatment of the wastes not removable from the industrial discharge. The beet-sugar industry and the liquor-distilling industry, as well as the milk-wastes field, have achieved notable success in the development of by-products for the improvement of living which was previously endangered by their discharge into water courses.

The proper approach to the ever-pressing problem of industrial-waste treatment is through a broadened sociological viewpoint. Decisions on the methods of treatment are intricately interwoven with the economic status of the industry, its employees, and society at large. It is significant that the hue and cry for elimination of industrial pollutants reached its crescendo while industry was in the doldrums, and that the industrial activity due to national-defense work will find processes ready for the handling of the greatly increased quantities of wastes which can be expected during the next few years. We cannot lose sight of national sanitation while we are being conscripted into intensive national-defense work.

The individual company cannot always afford to carry out reclamation studies while its competitor in a less-polluted-stream valley produces the same salable products without the secondary cost of pollution elimination. Furthermore, these small industries are an integral part of the economic life of communities and the treatment of their wastes is, to some extent, a moral obligation of the community itself. No municipality is justified in prohibiting the discharge into sewers of any material which can be water-transported through the sewer system, which will not injure the physical or sanitary condition of such system, and which can be treated at the sewage works without the production of nuisances, physical destruction of the treatment devices, or impairment of the ability of the plant to produce a suitable effluent.

Where the industry discharges into a water course directly, it is its responsibility to provide its own treatment; but where it discharges into a public sewer system, an amicable adjustment should be made between that portion of the treatment which should be provided at the plant and the portion which should be handled at the sewage works.

There is an ever-growing tendency to view sewerage service as a public utility which should "pay its own freight." It is reasonable that every sewer user should pay his proportionate share of the cost, based on the quantity of sewage and the complexity of the treatment problems which he imposes on the sewage works. However, this utility attitude may frequently be tempered with a sensible social and economic approach.

Since municipalities frequently make many concessions to bring industries into their limits, and often provide free sites and other local benefits, it is reasonable that they should not stifle the industry by imposing undue limitations on their use of the sewer system and of the charges made for this use. Those costs which do not return to the city by means of a sewer charge may often return by indirect channels, through the improved employment status of the residents and the greater ability of these residents to pay their tax bills.

Despite all of these economic complications, industrial wastes must be treated and streams must be clean. The answer to industrial-waste disposal lies in cooperation among the manufacturers in the industrial group itself and between the industry and the municipal or state agencies directly affected by the wastes. The Textile Foundation has demonstrated the value of industry research, and of coordinated efforts of municipalities and industry. Recent achievements in sew-

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age treatment make it possible to predict that there need be no unsolvable industrial-waste problems in America.

Comment by H. W. Gehm[10]

The complexity of the textile-waste problem, due to the character of the waste, is intensified by the differences in operation in various factories and changes within a given factory.

There is no universal type of treatment available which will treat every type of waste. The chances that a general type of treatment will be made available are slim, when we consider the various physical and chemical states of matter involved. We find in textile wastes both organic and inorganic compounds, some in solution and others in colloidal suspension. Acids, alkalies, salts, some of an oxidizing character and others with reducing properties, are present. The mill not in close proximity to a town has no other alternative than to treat the waste at the source. Even when connected to a municipal treatment system, some form of pretreatment is generally necessary.

The more important methods of pretreatment include (1) equalization, (2) segregation, (3) lagooning, (4) chemical treatment, (5) oxidation methods, and (6) dialysis.

Equalization. Irrespective of where the waste is to be discharged, equalization as to rate of discharge is a basic requirement. Even if the waste is discharged directly into a stream, this should be practiced if the greatest advantage is to be taken of the dilution afforded by the stream. If the waste is combined with domestic sewage prior to treatment, the dilution must also be considered, as slugs of waste can readily upset the treatment processes. Equalization provides a means of procuring a more uniform mixture than intermittent discharge of batches of various liquids. Intermittent discharge of wastes, varying widely in character from minute to minute, is extremely difficult or impossible of treatment by any process.

Another advantage in this procedure is that diverse wastes often react with one another to advantage. Acids neutralize alkaline wastes, oxidizing agents react with reducing compounds, while some precipitate or coagulate others, facilitating their removal from the waste water.

This form of pretreatment is eaily accomplished. Wastes are diverted to holding tanks with sufficient capacity to absorb variations in flow of waste from the mill, while discharging at a uniform rate.

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Segregation. Dilution of strong wastes by cooling and rinse waters is in some cases advantageous but in others decidedly detrimental. Dilution with equalization by direct discharge into a stream or into a municipal system is generally helpful and may prevent severe periodic pollution in the stream or complete upsetting of treatment processes. Mixing relatively clean water with strong waste is a poor practice if the mill intends to treat the waste. By allowing such dilution the application of some processes, particularly those involving possible recovery may be excluded. A small volume of concentrated waste, which could be treated in small units economically, is converted to a large volume of dilute waste which requires large treatment units and is more expensive to treat. Recovery of dye, for example, requires concentration of the dye. The purpose is defeated from the start. Chemical-treatment processes, which are now considered to be too costly, may work out better if applied to wastes in concentrated form.

Another factor is that some wastes inhibit or increase the difficulty of treatment of other wastes.

Segregation and separate handling of a small volume of one or two wastes might render treatment of the greater volume simpler.

Lagooning. Storage of wastes in lagoons for protracted periods of time is a method whereby textile wastes have been handled. Such a procedure is seldom a permanent solution to the problem. It is a method of delaying a better solution to the problem.

Lagoons of textile waste are unsightly, frequently odorous, causing nuisances. This method should be resorted to only when the quantity of waste is small and a better method of disposal is not feasible.

Chemical Treatment. The author states that chemical-coagulation processes for the removal of suspended matter in textile waste are expensive. This is true of present processes and here indeed is a fertile field for research. When several factors are considered, this method has certain attractive features and, when properly executed, may not prove as expensive as first believed. Coagulation processes are applicable only where there is oxidizable matter in suspension. Many of the dye wastes contain high concentration of salts and it is the action of these salts which renders the spent dye in the waste difficult to coagulate.

Admixture with other wastes which do not benefit by this form of treatment further complicate the problem; that is, we should treat only that portion of the waste which will respond to this form of treatment. Segregation, therefore, might change the economic picture in some cases, but another factor is the recovery of spent dyes.

Other types of chemical treatment are neutralization of acid wastes with lime, and alkaline wastes with acid. These are easily and economically accomplished by equalization followed by feeding lime, sulphuric acid, or aeration with flue gases. The destruction of reducing substances by chemical means has been tried but is not economical. Some loss in reducing qualities is obtained by simple aeration but generally the amount destroyed by this method is small.

Oxidation Methods. The common oxidation methods of sewage treatment are not applicable to textile wastes alone. The wastes are not biologically active and generally contain substances toxic to bacteria. The waste must be diluted with about 10 times its volume of domestic sewage before oxidation methods can be used. Such methods are the only ones we have that will give complete treatment of most dissolved organic wastes. There are no chemical means of complete treatment of textile wastes because many of them contain dissolved organic matter which cannot be precipitated.

New Methods. Experiments have been made in which electrodialysis has been applied to the treatment of certain dye wastes. The salts which tend to prevent coagulation of the dye are dialyzed through an asbestos membrane, after which procedure the dye is readily precipitated.

The application of new chemicals, employing the principle of sensitization, has been tried on dye wastes in the laboratory. Results showed promise that new chemicals might be developed which would substantially aid the chemical-treatment process as applied to textile waste.

Consideration of the methods of treatment mentioned leads to the conclusion that at present textile mills cannot treat their wastes completely with the methods at hand. They can provide partial treatment but even this is obtained only at rather high cost. A mill can prepare the waste for successful treatment in a municipal plant when there is sufficient volume of sewage for dilution. Each mill, however, must be considered as a problem in itself.

The excellent research program fostered by the Textile Foundation has given a start and pointed out means of attacking this problem. The problem of treatment, however, is not solved and must not be considered so if we are to make further progress.

A.S.M.E. BOILER CODE

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Anyone desiring information on the application of the Code is requested to communicate with the Committee Secretary, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are then sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and is passed upon at a regular meeting of the Committee.

This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval after which it is issued to the inquirer and also published in MECHANICAL ENGINEERING.

Following is a record of the interpretations of this Committee formulated at the meeting of March 21, 1941, subsequently approved by the Council of The American Society of Mechanical Engineers.

CASE No. 732 (Reopened)

(Special Ruling)

Inquiry: May open-hearth process steel which meets A.S.T.M. Specifications A7-39 for Steel for Bridges and Plates, A10-39 for Mild Steel Plates, A78-39 for Steel Plates of Structural Quality for Forge Welding, and Specification S-53 for Boiler and Firebox Steel for Locomotives of a tensile strength of 55,000 to 65,000 lb per sq in., be used for Par. U-70 fusion-welded unfired pressure vessels having a shell thickness of $^1/_4$ in. or less provided it is of good weldable quality, the working stress does not exceed 5600 lb per sq in., and all other code requirements are met?

Reply: It is the opinion of the Committee that with the restrictions as stated in the inquiry, these materials may be used in the construction of Par. U-70 vessels.

CASE No. 896 (*Reopened*)

(Special Ruling)

Inquiry: Is it permissible under the rules of Section VIII of the Code to construct fusion-welded pressure vessels of integral alloy-lined plate material in accordance with following requirements?

The alloy facing shall conform to one of the following analyses:

A.I. & S.I. Type No.	A.S.T.M.	Grade
410	A176-39	2
430	A176-39	4
446	A176-39	6
304	A167-39	3
310	A167-39	10
316	A167-39	11
317	A167-39	12
321	A167-39	5
347	A167-39	6

The chemical composition of the base plate material shall meet the requirements of any one of the following steel plate specifications which are approved for fusion welding: S-1, S-42, S-44, and S-55, respectively, known as A.S.T.M. Specifications A70, A201, A204, and A212.

An integral alloy-lined plate is defined as a composite plate having an alloy face and a relatively thick steel base sufficiently bonded thereto substantially throughout to show a shear strength of not less than 20,000 lb per sq in. when tested as shown in Fig. 37.

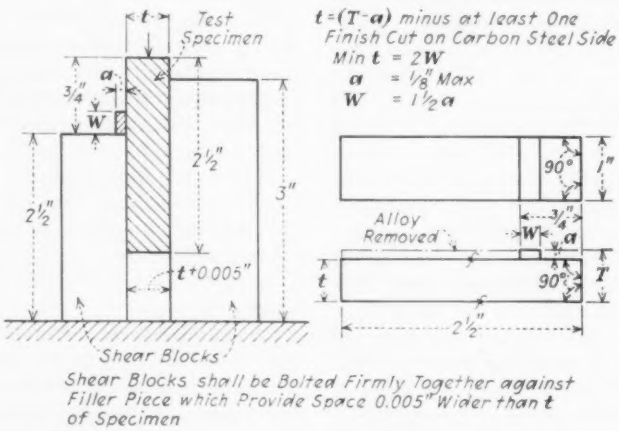


FIG. 37 INTEGRAL ALLOY-LINED PLATE FOR WELDING PRESSURE VESSELS

The physical properties of the composite plate shall be equal to or greater than the minimum requirements of the steel-plate specification used in design. Duplicate bend tests shall be made, one with the alloy surface in tension and the other with the alloy surface in compression. Both shall meet the bend-test requirements of the specification for the base plate material.

Reply: It is the opinion of the Committee that subject to the rules of Section VIII of the Code, fusion-welded pressure vessels may be constructed of integral alloy-lined plate material subject to the following additional requirements:

(1) It is expected that vessels of alloy-lined plate covered by these rules will be used to hold liquids and gases corrosive to ordinary materials, but the selection of an alloy suitable for the vessel's contents and the determination of corrosive allowances is not covered by these rules.

It is recommended that users assure themselves by appropriate tests, or otherwise, that the alloy selected and the treatment following fabrication are suitable for the service intended.

Where service data are not available, the procedure of Par. U-11(*b*) should be followed.

(2) The alloy facing shall have a chemical composition of any of the alloys specified in the inquiry.

(3) The chemical composition of the base plate material shall be in accordance with an approved plate-steel specification.

(4) The minimum physical properties of the composite plate shall be equal to or greater than those required by the steel-plate specifications used in design.

(5) All integral alloy-lined plates shall show a minimum shear strength of 20,000 lb per sq in. when tested in the manner indicated and described in Fig. 37. One shear test shall be made on each rolled plate and results reported by the mill.

(6) The carbon steel base plate shall be marked with the name or brand of the manufacturer, the manufacturer's test identification number, specification number of the base material, specification number and grade of the alloy face material, by stamping legibly on each finished plate in two places not less than 12 in. from the edges. The manufacturer's test identification number shall be legibly

stamped on each test specimen. For plates under $^1/_4$ in. in thickness, the marking shall be legibly stenciled instead of stamped.

(7) Process, operator, and vessel test plates shall include duplicate bend specimens, one with the alloy surface in tension and the other with the alloy surface in compression, both of which shall meet the elongation requirements of the class of construction (Pars. U-68, U-69, or U-70) involved, with the elongation measured over a gage length of not less than $^1/_2$ in. including the weld.

The all-weld metal tension bar required by Par. U-68(*d*) shall contain no stainless alloy on the gage length. Where not enough carbon steel weld metal is available for the standard 0.505 bar, it may be omitted.

(8) Vessels constructed of types 430 and 446 composite materials shall be limited to a service temperature of 800 F. In no case shall the service temperature for vessels constructed of composite materials exceed the limiting temperature given in Table U-2 for either the backing or facing material used.

Stress relief shall be mandatory for vessels constructed of type 410 composite material.

Because of the danger of cracking when welding composite plates of types 410, 430, and 446 with straight chromium steel rods, X-ray examination of all main seam welds is mandatory for Pars. U-68 and U-69 vessels, while the completed alloy welds for Par. U-70 vessels shall be carefully examined for cracks. Where austenitic rods are used on these types, no X ray is required for Pars. U-69 and U-70 vessels.

(9) The types of joints used shall be such that steel weld metal shall not fuse into the stainless layer and the depth of the stainless bead shall be kept to a minimum.

(10) The full thickness of the composite plate may be used in design calculations for all classes of construction where corrosion is not expected.

The allowable stress shall be based on the specified minimum tensile strength of the composite material and shall not exceed the values given in Table U-2 for the grade of steel used for the backing material.

(11) Where corrosion of the liner material is expected, additional metal thickness should be provided. In such cases the thickness added for corrosion shall be removed from the alloy face of all tensile bars before testing.

CASE No. 897

Change items (2) and (7) as follows:

(2) *Specifications*. The alloy chrome-nickel material shall conform to A.S.T.M. Specifications A240-40T for sheets and plates subject to the following added restrictions and requirements. Structural shapes, bars, tubes, pipe, and forgings made to the same specifications, so far as applicable, may be used:

a Marking. In addition to the marking required by the specification the heat-treatment ((3)*a*, *b*, or *c*) shall be marked in like manner.

(7) *Allowable Working Stresses*. Allowable working stresses in pounds per square inch shall be those given in Table U-2 for A.S.T.M. Specifications A167-39 until such time as they are replaced by corresponding stresses for A.S.T.M. Specifications A240-40T.

CASE No. 923

(Interpretation of Par. P-299(a))

Inquiry: Par. P-299(*a*) requires that all valves and fittings shall be marked with the name or trademark, or other identification of the manufacturer, and the maximum allowable working pressure. At the present time the standards of the Manufacturers Standardization Society of the Valve and Fittings Industry do not call for the pressure markings of the following fittings:

(1) Cast iron screwed fittings for 125 lb working pressure;
(2) Malleable iron screwed fittings for 150 lb working pressure;
(3) Nonferrous screwed fittings for 125 lb and 250 lb working pressure;
(4) Cast iron and nonferrous companion flanges.

Is it permissible to install the above-listed fittings without the required pressure markings until such time as the M.S.S. adopt these markings as their standards?

Reply: It is the opinion of the Committee that, inasmuch as the M.S.S. has not adopted the pressure marking of the fittings mentioned in the inquiry, these fittings will be considered as meeting the requirements of the Code until suitable revisions can be made for markings in accordance with Par. P-299(*a*).

CASE No. 924

(Special Ruling)

Inquiry: Under the provisions of Par. P-112(*d*) at least one of the operators performing field welding must have been regularly employed upon production work of the character defined for a period of at least one year. No difficulty was encountered with this requirement under normal employment conditions. Due to the present volume of work and lack of men available with the above qualification, it is extremely difficult to meet this employment requirement and relief is requested.

Reply: It is the intent of this paragraph to insure that field welding be under the supervision of a competent person. It is the opinion of the Committee that due to present conditions, the one year employment requirement in Par. P-112(*d*) may be waived, if the operator has been qualified under Par. A-115 using test positions 3B, 4B, 3F, and 4F, is experienced in the production of such welds, and the inspector is satisfied as to the operator's competency.

CASE No. 925

(Special Ruling)

Inquiry: Since Specification S-12 has been discontinued and Specification S-56 adopted, it has been difficult to obtain alloy steel castings for valves that conform to the new specifications. May valves made of material conforming to former Specification S-12 be used under the Code rules until the new specifications come into more general use?

Reply: It is the opinion of the Committee that material complying with former Specification S-12 may be used under the Code rules.

CASE No. 926

(Interpretation of Par. U-73(c))

Inquiry: Par. U-73(*c*) of the Code provides that circumferential joints of vessels covered by Pars. U-68 and U-69 shall be of the double-welded butt type (except that for Par. U-69, on thicknesses of $^5/_8$ in. or less, it is permissible to use a single-welded butt type). When it is necessary to install a steel plate intermediate head, it requires a very cumbersome detail to comply with the above rules (See upper sketch of such a joint on existing tanks in Fig. 38 in which the girth butt joint in the shell cannot be satisfactorily inspected after the vessel is completed). Will it be permissible to use the detail shown on the lower sketch in Fig. 38?

Reply: It is the opinion of the Committee that a steel plate intermediate head may be inserted in a pressure vessel covered by Pars. U-68 and U-69, provided that:

(1) The outside diameter of the head flange is a close fit inside of the overlapping ends of the adjacent lengths of cylinder;

(2) The width of the girth butt-weld formed between the ends of the lengths of cylinder referred to and backed up by the outside surface of the intermediate head flange is at least twice the shell plate thickness;

(3) The edges of the girth butt-weld formed between the ends of the lengths of cylinder referred to and backed up by the intermediate head flange are respectively distant from the tangent point of the head curvature by twice the head plate thickness, (and in no case less than $^1/_2$ in.), and from the edge of the head flange by twice the shell plate thickness.

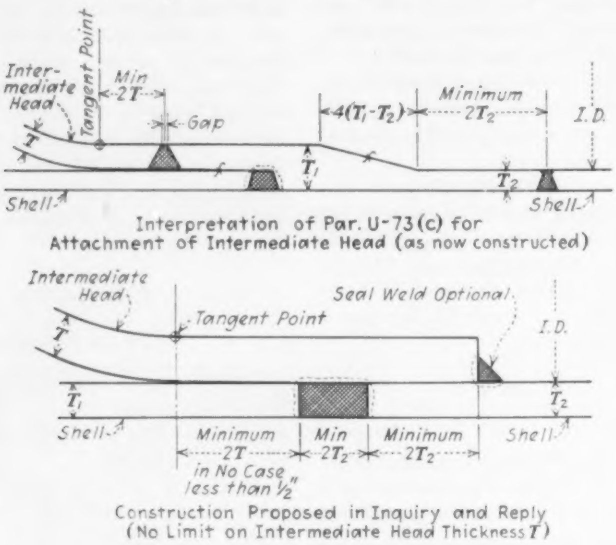


FIG. 38 INTERMEDIATE DISHED AND FLANGED HEADS

CASE No. 927

(Interpretation of Par. U-94)

Inquiry: Par. U-91 permits the use of any of the materials specified in Par. U-71, which materials have varying tensile ranges. Par. U-94 provides, however, for only a single unit working stress of 9900 lb per sq in. Is this correct?

Reply: When Par. U-94 was originally written, steel of 55,000 to 65,000 lb per sq in. tensile range was in common use; since then specifications for steels of other types have been incorporated in the Code. It is the opinion of the Committee that the intent of Par. U-94 is that the unit working stress shall be 90 per cent of the maximum allowable working stresses shown in Table U-2 for the materials covered in Par. U-71.

Revisions and Addenda to Boiler Construction Code

IT IS the policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision of the rules and its code. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the code, to be included later in the proper place in the code.

The following proposed revisions have been approved for publication as proposed addenda to the code. They are published below with the corresponding paragraph numbers to identify their locations in the various sections of the code, and are submitted for criticism and approval from anyone interested therein. It is to be noted that a proposed revision of the code should not be considered final until formally adopted by the Council of the Society and issued as pink-colored addenda sheets. Added words are printed in SMALL CAPITALS; words to be deleted are enclosed in brackets [ ]. Communications should be addressed to Secretary of the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Committee for consideration.

PAR. P-1 (*a*). Transfer (*c*) to (*a*) and revise to make it identical with proposed revision of Par. U-12 (*c*) which appeared in the April, 1941, issue of MECHANICAL ENGINEERING, substituting the word "boilers" for the words "unfired pressure vessels."

PAR. P-113. Delete the words "and not exceeding $2^1/_2$ in. diameter" in the first sentence.

PAR. P-271. In the third sentence insert the words "saturated steam safety" before the words "valves on a boiler."

FIG. P-47. Add a line reading "Heating surface in sq ft, boiler . . . . waterwalls. . . . ."

TABLES P-7 AND U-2. Revise as follows:

S-18, Low carbon, 48,000(3). Change "low carbon" to "Grade A," and modify stresses as follows:

Temperature F	Stresses
—20 to 650	9600
700	9250
750	8700
800	8000
850	6850

Values above 850 F to remain as at present

S-18, Low carbon, 48,000. Change "low carbon" to "Grade A," and modify stresses as follows:

Temperature F	Stresses
—20 to 650	9600
700	9100
750	8250
800	7250

Values above 800 F to remain as at present

S-18, Medium carbon, 62,000(3). Change "medium carbon" to "Grade B." and tensile to "60,000;" change value at 700 F from "12,-000" to "11,400;" values at other temperatures to remain as at present.

S-18, Medium carbon, 62,000. Change "medium carbon" to "Grade B," and tensile to "60,000;" change value at 700 F from "12,-000" to "11,400," and at 750 F from "10,400" to "9950;" values at other temperatures to remain as at present.

S-18, Lapwelded and butt-welded, 45,000. Change values at 700 F from "8800" to "8500," and at 750 F from "8400" to "7800;" values at lower temperatures to remain as at present. For butt-welded pipe, omit all values above 750 F.

New Specifications—The following specifications are to be referred to in the paragraphs indicated:

S-58 (A135-34). Par. P-3; Tables P-5 and P-7; P-103 (*a*); Table A-14 insert after S-18 indicating Order No. 1 with Grades or Class blank; Table U-2; U-71 (*a*); U-120; Table UA-18 and Table MA-1, to be made the same as Table A-14.

S-59 (B57-27)—Table U-3.

S-60 (A225-39T). Par. P-2 (*a*); Table P-7; P-103 (*a*); Table A-14 insert after S-58 with Order No. 1 and Grades A and B; U-13 (*a*); U-13 (*c*) requiring stress relief for both grades; Table U-2; U-71 (*a*); U-120; Tables UA-8 and MA-1 to be made the same as A-14; L-2; L-3; L-5.

S-53. Par. L-5.

M-11. Insert the following as the th :d sentence:

Boilers not exceeding 12 in. internal diameter and having less than 10 sq ft of heating surface, need have not more than two 1-in. openings for clean outs, one of which may be used for the attachment of the blow-off valve; these openings shall be opposite to each other where possible.

PAR. U-17. Change "$^1/_8$ in." to "$^3/_{32}$ in."

PAR. U-13 (*c*). Add the words "or seamless tube or pipe not greater than 24 in." to the first section of this paragraph as printed in May, 1941, MECHANICAL ENGINEERING.

PAR. U-66 (*a*). Revise fifth section to read: "When an unfired pressure vessel unit consists of more than one pressure chamber operating at the same or different pressure, each such

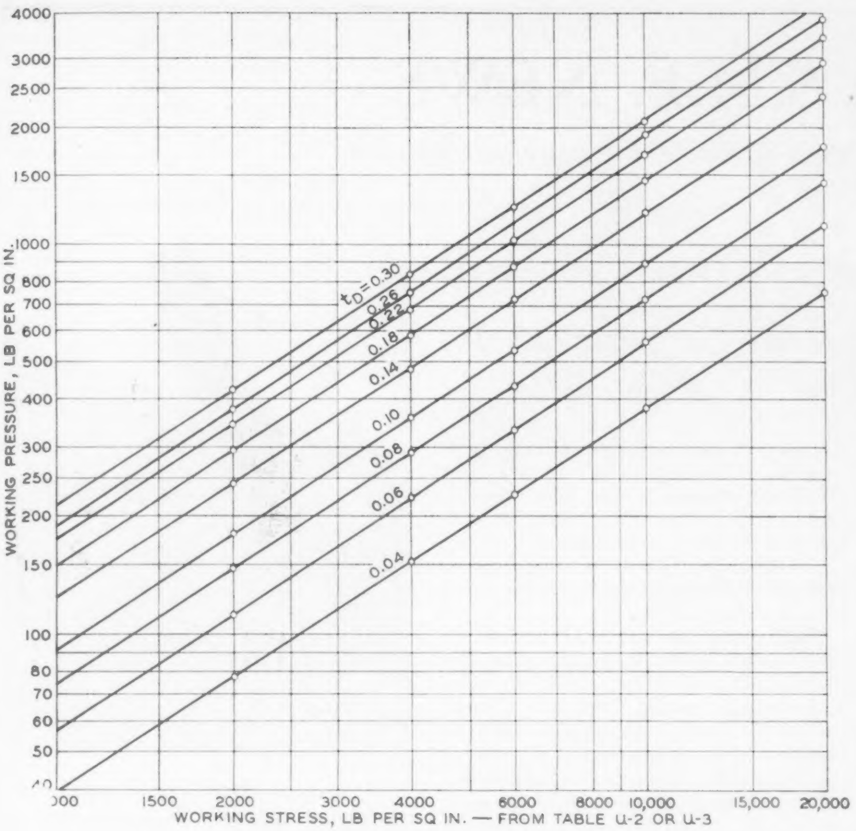


FIG. U-19½ CHART FOR DETERMINING WALL THICKNESS FOR TUBES UNDER EXTERNAL PRESSURE

pressure chamber (vessel) WHICH OPERATES AT A PRESSURE ABOVE 15 LB PER SQ IN., shall be subject to the required inspections and hydrostatic tests. THE PART OR PRESSURE CHAMBER TESTED SHALL BE STAMPED SO AS TO INDICATE THAT THE STAMPINGS APPLY ONLY TO THE CHAMBER (VESSEL) TESTED, SUCH AS "JACKETS ONLY," "STOCK SPACE ONLY," ETC.

PAR. U-71 (*a*). Include reference to Specification S-32 in the first two sections.

PAR. UA-18 (*b*). Add the following sentence:

This does not apply to integral connections.

PAR. U-20 (*c*). Replace by the following:

(*c*) *Tubes and Pipes.* The maximum allowable working pressure in lb per sq in. for ferrous and nonferrous tubes and pipes shall be determined as follows:

Ferrous tubes and pipes, internal pressure

The following formula shall be used

$$P = \frac{2.3\,St}{D} - \frac{S}{30}$$

where P = maximum allowable working pressure, lb per sq in.,
t = minimum wall thickness, in.,
S = maximum allowable working stress from Table U-2 (*a*),
D = outside diameter of pipe, in.

Nonferrous tubes and pipes, internal pressure

The following formula shall be used

$$P = \frac{2\,St}{D}$$

where P = maximum allowable working pressure, lb per sq in.,
t = minimum wall thickness, in.,
S = maximum allowable working stress from Table U-3,
D = outside diameter of pipe, in.

Ferrous tubes and pipes, external pressure

The maximum allowable external pressure shall be determined from Fig. U-19½, using stresses as provided in Table U-2 (*a*).

Nonferrous tubes and pipes, external pressure

The allowable external pressure shall be determined from Fig. U-19½ using the stresses provided in Table U-3.

The foregoing rules are subject to the following restrictions:

(1) Applicable only to outside diameters of ½ in. to 6 in., inclusive, and for wall thicknesses not less than 0.049 in.;

(2) Additional wall thickness should be provided when corrosion or wear due to cleaning operations is expected;

(3) Where tube ends are threaded, additional wall thickness is to be provided of 0.8 divided by number of threads per inch;

(4) The requirements for rolling or otherwise setting tubes in tube plates may require additional wall thickness.

PARS. P-103 (*a*) AND U-71 (*a*). Revise as follows:

(*a*) Material. The materials used in the fabrication of any fusion-welded drum, shell, or parts, covered by this Code shall conform to Specifications S-1, S-2, S-4, S-25, S-28 grade A, S-42, S-43, S-44, S-55, or S-60 of Section II of the Code. Pipe or tubing shall conform to Specifications S-17, S-18, S-19, S-32, S-34, S-40, S-45, S-48, S-49, S-52, or S-58. ROLLED OR FORGED PIPE FLANGES SHALL CONFORM TO SPECIFICATIONS S-8, S-35, OR S-50. STEEL CASTINGS SHALL CONFORM TO SPECIFICATIONS S-11, S-33, S-56, OR S-57. The carbon content in all such materials shall not exceed 0.35 per cent.

Books Received in Library

POWER IN TRANSITION. By E. R. Abrams. Charles Scribner's Sons, New York, N. Y., 1940. Cloth, 5½ × 8½ in., 318 pp., maps, tables, $3. The development of the electrical utilities is briefly described up to the peak of private operation. In the succeeding chapters the growing tendency toward public control is considered. Some sixty major power projects are analyzed, their history through Congress is traced, engineering problems are discussed, and the resources, requirements, and expectations of the several regions to be served are carefully detailed. Probable effects of these developments of the national power policy are briefly pointed out in a final chapter. There are chapter bibliographies.

PUBLIC UTILITIES AND THE NATIONAL POWER POLICIES. By J. C. Bonbright. Columbia University Press, New York, N. Y., 1940. Cloth, 5½ × 9 in., 82 pp., $1.25. This sketch of the New Deal power policies discusses the control of public utilities, rate regulation, holding companies, etc., and their relation to the question of public ownership. The electric-light and power industry is used as an example, and the criticisms of present government policy are discussed. Suggestions are given for further reading.

STRESS ANALYSIS AND DESIGN OF ELEMENTARY STRUCTURES. By J. H. Cissel. John Wiley & Sons, Inc., New York, N. Y., 1940. Cloth, 6 × 9½ in., 335 pp., illus., diagrams, charts, tables, $4. Fundamental and practical material which would generally be of value to an engineer in any field is presented in this textbook, which is primarily intended for engineering students other than civil. The section on stress analysis covers external forces and loads, graphic statics, beams, trusses, masonry structures, and foundations. The elementary design section covers structural fastenings and connections, timber, steel, and reinforced-concrete beams and columns.

TEXTILE RECORDER YEAR BOOK, 1940. Edited by W. Hubball and others. Harlequin Press, Manchester, England. Cloth, 5 × 7 in., illus., diagrams, charts, tables, 10s 6d. Encyclopedic in scope, this annual publication furnishes technical information upon the production, preparation, spinning, weaving, dyeing, and finishing of all textile fibers. There are also sections on hosiery and knitting, microscopy and testing, and power transmission. Patent and trade-mark information is given, and a classified list of recently introduced textile machines and appliances is included.

VDI-FORSCHUNGSHEFT 403. Die mechanischen Eigenschaften verschieden feuchter Hölzer im Temperaturbereich von —200 bis +200 C. By F. Kollmann. V.D.I. Verlag, Berlin, Germany, July-August, 1940. Paper, 8 × 12 in., 18 pp., illus., diagrams, charts, tables, 5 rm. The method and results are presented of an investigation concerning the mechanical properties of damp wood under varying conditions within a temperature range from —200 to +200 C. There is a bibliography.

A.S.M.E. NEWS

And Notes on Other Engineering Activities

Kansas City Awaits Your Arrival!

At A.S.M.E. Semi-Annual Meeting, June 16–19, Headquarters, Hotel Muehlebach

THE Semi-Annual Meeting is almost here! Kansas City, your host, awaits your arrival. The authors, guest speakers, and entertainers are ready. If you don't have a grand time—intellectually and socially—it's because you will be among the few who don't attend.

Remember the specifications! To wit:
June 16, 9:30 a.m. through Thursday, June 19
Headquarters, Hotel Muehlebach, 12th and Baltimore Streets
Send in the information post card, if you have not done so already.

In spite of the urgent requirements of rearmament the program is virtually unchanged except for improvements. The number and quality of paper and authors guarantee a topnotch technical program. The diversity of subjects fits the requirements of all, both as to your business interests and as to your pet hobbies and side lines. Schedules have been arranged to give you the maximum opportunity to hear the papers you desire. With these assurances as to technical features, let's turn to the lighter part of the program.

Its Easy to Eat in Kansas City

Meals? Monday you are on your own because we believe the visitor harbors something of the pioneering spirit. The hotel has several excellent places—dining room, Rendevous, Terrace Grill, and Coffee Shop, but if you prefer to wander, we suggest the Airport Grill, or the Harvey House at the Union Station, Nance's on the Station Plaza, or several establishments in Country Club Plaza. All are within ten minutes' ride of the hotel. Monday night would be a grand time to see the friends you meet all too seldom.

Tuesday's luncheon with the Engineers Club of Kansas City and other local organizations will be held in the hotel, as will the buffet dinner Tuesday evening. Wednesday's luncheon will be another chance to get together between sessions. At night you will attend the banquet at which the Spirit of St. Louis Medal will be awarded to Prof. John E. Younger.

Take the Coal-Mine Trip

Thursday you will be on your own—as to meals—unless you go on the strip coal-mine inspection trip (and our advice is to be sure to take this trip). Which reminds us to repeat last month's suggestion, that the inspection trips will be not only informative but interesting. Plan to make as many as possible.

TWA Maintenance Shops are their main shops and service everything from blind-flying trainers and experimental or laboratory ships to Stratoliners. The Sheffield Steel plant is somewhat of a specialty plant and well worth a visit. By the way, defense regulations have not closed TWA and Sheffield doors to you, but a few credentials in your pocket might not be amiss since much can happen between the time this is written and June 16. Phillips Refinery and the Northeast Generating Station are bound to interest you. The former rivals the stockyards in use of raw materials without waste. The latter was one of the early stations to top.

32-CUBIC-YARD STRIPPING SHOVEL
(Strip pit operation at Sinclair Coal Co., to which a trip is planned during Semi-Annual Meeting.)

TWA HANGAR AT KANSAS CITY, MO., WILL BE VISITED DURING SEMI-ANNUAL MEETING

The scheduled inspection trips do not scratch the surface on possibilities available for meeting individual desires. The committees and local members will gladly arrange, wherever possible, for other inspection trips for individuals or small groups. Among these possibilities are the stockyards, grain elevators, soap factories, corn-products refinery, paint manufacturers, two water works, Kansas City, Kansas, steam power plant (one of the larger municipal power plants), and a variety of other industrial enterprises.

Country Club District Nationally Known

Possibly the pioneering spirit will show itself in other ways than finding new places to eat. If so, we suggest a bit of local urban and rural sight seeing, even if it takes an extra day. The Country Club District is a nationally known project of merit. Planned and executed as a series of integrated units, this district is a complete city within a city. The County Club Plaza is an outlying commercial center created in the image of beauty and studded with gems of convenience. Shops are housed in buildings conforming to a basic architectural theme, free parking lots abound, and high standards of shop and building appearance are maintained.

Radiating from the Plaza to the south, southwest, and west are various developments such as Country Club, Mission Hills, Indian Hills, Fieldston, Romanelli Gardens, and others. Although laced with direct streets, the district abounds with winding drives. Modest homes and mansions alike are frequently enhanced with small parks and plots containing surprisingly beautiful statuary and fountains.

Interwoven with this residential district are several excellent golf courses. Other courses are scattered over the city and in the near-by area. Your golf taste can be filled from flat courses to those with many traps and water hazards—your correspondent once counted over sixty traps on one course before dark and never finished the course!

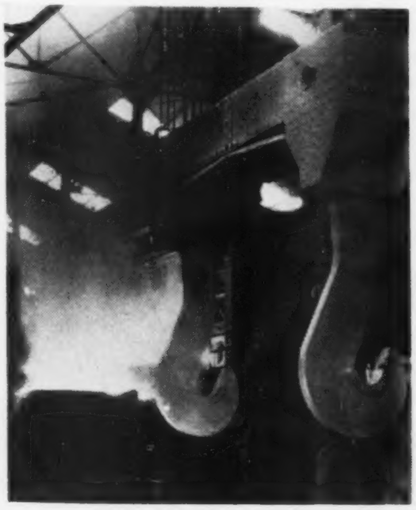
Perhaps art is a real friend of yours. The Nelson Gallery is a notable institution and at present houses many treasures from Europe. New rooms in the west wing have just been opened and they are furnished with the most modern and advantageous equipment obtainable to display art. Your wife is scheduled to visit the Gallery and no doubt she will suggest another visit so you too may see these treasures from Old Masters to Indian works of art, paintings to pottery, and carvings to statuary.

Hotel Near Shops and Theaters

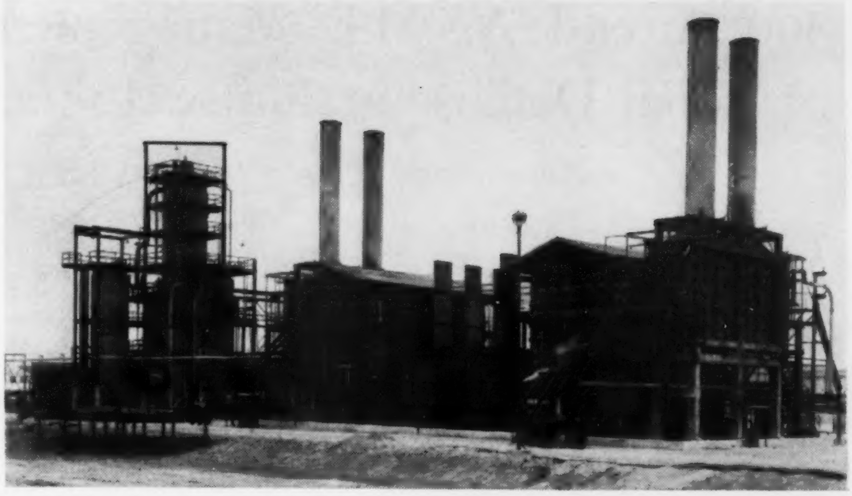
Your hotel is adjacent to shops and theaters. The ball park is not far away and the Kansas City Blues play great ball. You possibly remember that Rizzuto, Priddy, Sturm, Bonham, and others came up to the Yanks, Vince Di Maggio to the Pirates, as well as Jurges, Judnich, Eddie Miller, Mike Kreevich, and many others made good with other teams. Yes, they play here during convention week.

Let's Go

Kansas City and the local section want you to enjoy the Semi-Annual Meeting and your visit to the Heart of America. The ladies, so our ebullient "Mrs. Kansas City" says, are planning to make your lady folk feel at home among your friends. The latch string is out!



TRIP PLANNED TO OPEN-HEARTH PIT, SHEFFIELD STEEL CORPORATION, KANSAS CITY
(Showing 120-ton "heat" of steel being "tapped" from one of the open-hearth furnaces.)



KANSAS CITY, KAN., PLANT OF PHILLIPS PETROLEUM COMPANY
(Inspection trip is planned during Semi-Annual Meeting to this plant whose function is to convert crude-oil distillates into high-octane motor fuel.)

To the Ladies! Encore

Dear Mrs. A.S.M.E.:

How goes the campaign to get you to Kansas City for the Semi-Annual Meeting, June 16–19? Is the Head of the House amenable to reason? Or, as the younger generation so elegantly phrases it, "What cooks?"

As spring bursts on us in a shower of spirea and snowballs, we're increasingly thrilled at the prospect of welcoming you. You know the old rule: An actor never plays his best to an empty house; the audience is quite as important as he is. This time, dear Mrs. A.S.M.E. you'll have the fun of playing a dual role, both audience and actor, with our committee as the sceneshifters. We're up to our plucked eyebrows in plans for your entertainment, and the more who come, the merrier we'll be.

Flashback

We hope, of course, that our first letter is parked under the check book, or wherever you file important "musts." In case Junior made the fatal error of including it in the schoolpaper sale while you argued with the dandelions, let us briefly review the program. First of all, we want you to remember that our time is your time while you're here, and you will find a competent reception committee—even our husbands admit it when cornered, and an engineer can't afford to be wrong—to check you in, introduce you to Mrs. Whoosit in the next room, and act as a general Information, Please.

On Tuesday, the 17th, there will be a luncheon, a tour of the city, and the informal buffet supper with the men. Wednesday we hope you will enjoy the Nelson Art Gallery, tea at the University Women's Club, and the formal banquet. Culture can go with the wind on Thursday while we let down our hair over the luncheon and bridge tables, and rumor has it—good old reliable rumor—that there will be draw prizes for those who scorn Culbertson, Blackwood, et al. This is such a skeleton it fairly rattles its bare bones, and there will be plenty of other interests, golf, shopping, lovely drives, and even that marvelous institution, sleep, to round it out. In fact, we dare you not to have a wonderful time every minute.

Go Easy on the Clothes

Clothes may make the man, but whoever heard a woman called a stuffed shirt? Please make 'em simple and practical so the committee won't be too embarrassed, and concentrate instead on the important fact that you're coming. The time? June 16–19. The place? Kansas City. The girl? YOU.

Till then, and always, Your Friends.

A.S.M.E. National Nominations

MEMBERS of The American Society of Mechanical Engineers are invited to appear before the A.S.M.E. Nominating Committee at its open meeting on June 17, 1941, at the Hotel Muehlebach, Kansas City, Mo., headquarters for the Semi-Annual Meeting of the Society. Any time between 10 a.m. and 4 p.m. on that day the Committee will be glad to hear any member express his views or discuss matters pertaining to the selection of nominees for elective offices in the A.S.M.E. for 1942.

The personnel of the Committee and other pertinent information on nominations was published on page 160 of the February, 1941, issue of MECHANICAL ENGINEERING, and members of the Society are urged to read this over to refresh their memories.

300 Attend A.S.M.E. Management Conference on National Defense at Philadelphia, April 22 and 23

Past-President William L. Batt Receives Gantt Medal

ATTRACTING an attendance of about 300, the Management Conference on National Defense, held at the Philadelphia Engineers Club, April 22 and 23, and sponsored jointly by the Management Division and the Philadelphia Section of The American Society of Mechanical Engineers, afforded opportunity for the presentation of up-to-the-minute papers on subcontracting problems, selection and training of workers, labor problems under national defense, and quality control that excited extensive and animated discussion, and for the presentation of the Gantt medal to William L. Batt, past-president A.S.M.E., president SKF Industries, Inc., Philadelphia, Pa., and deputy director, Production Division, Office of Production Management, Washington, D. C. In addition to enjoying the privileges of the Philadelphia Engineers Club for the sessions of the Conference, engineers in attendance were able to attend luncheons of the Club on the two days of the Conference, at which special addresses were delivered.

Subcontracting Presents Many Problems

The conference was opened by Harold B. Bergen, partner, McKinsey and Company, New York, N. Y., chairman, A.S.M.E. Management Division, who introduced Marvin Bower, another partner of the same company, who presided.

Two phases of subcontracting were presented. The organization of the Defense Contract Service into districts centered in each of the Federal Reserve Banks and the work of the Service in the Philadelphia District, for which Thomas S. Gates, president of the University of Pennsylvania, is district coordinator, were described by William Steele, 3rd, of that district. The paper ably supplemented the one presented by Robert L. Mehornay, Jr., director of Defense Contracts Service, Office of Production Management, delivered at the Third A.S.M.E. National-Defense Meeting held in Cleveland in March.

Mr. Steele said that the subcontractor's problems were essentially, first, to get the subcontracts; second, to be able to finance them; third, to have available the necessary equipment and material to fulfill the order; and fourth, to have a sufficient labor supply, and, of course, to be able to produce the material ordered.

The Defense Contract Service, he said, would act as a clearing house for all information pertaining to defense orders, serving both the contractor and the subcontractor. At present, it was making an analysis of, and cataloging, all the machine tools in the district. When any contractor or subcontractor needed a special tool or piece of equipment to do a certain job, the service would be able to tell him where that equipment was located so that he could negotiate a subcontract. It would be able to tell the manufacturer looking for subcontracts where to go and to whom to go to find work. It would have available at its office blueprints and specifications for certain materials on which bids were being asked by the Army and the Navy. It had priority forms, information on contracts which had been placed, and other useful information. It hoped to save the contractors' time and make it unnecessary for them to go to Washington for many things. In brief, the Service was organizing to do everything that must be done to increase production and speed up deliveries in its district. With the cooperation of the Federal Reserve banks it would be able to assist manufacturers in their financial problems when they were unable to get accommodations at their local banks.

How Sperry Does It

How the Sperry Gyroscope Company, Brooklyn, N. Y., has been utilizing the facilities of outside firms in handling the greatly increased production demanded by the expansion of the aircraft industry, the War in Europe, and the National-Defense Program in this country was explained by L. B. Coon, planning manager of that concern. The Sperry plan and procedure were outlined in a paper read at the 1940 A.S.M.E. Annual Meeting, by P. R. Bassett, which appeared in the February, 1941, issue of MECHANICAL ENGINEERING. Mr. Coon amplified the details covered in Mr. Bassett's paper.

Under the skillful direction of Mr. Bower the discussions of the two papers were conducted jointly and were well-coordinated to bring out the essential factors of the subcontracting problem. The basis on which subcontracting firms may be discovered and allotted contracts was thoroughly discussed, and the interrelationships and responsibilities of subcontractor and prime contractor were brought out. Considerable information relating to the experience of the Westinghouse Company and the TVA resulted from the discussion. An impressive feature of the testimony was the wholehearted cooperation which exists between subcontractors and prime contractors and the extent to which some prime contractors have gone in making available shop, production, and management techniques for the benefit of smaller and less experienced concerns.

Staples Tells About Franklin Institute

Adjourning for the regular Tuesday luncheon of the Philadelphia Engineers' Club, at which H. S. Murphy, president of the Club presided, members of the Conference joined with members of the Club in listening to an address "Scientific Work of The Franklin Institute," by P. C. Staples, president of the Bell

(*Continued on page 489*)

Courtesy Philadelphia Chamber of Commerce

PAST-PRESIDENT BATT RECEIVES GANTT MEDAL

(William L. Batt, president of SKF Industries, Inc., Philadelphia, and deputy director of production, Office of Production Management in Washington, is shown (second from right) receiving the Gantt Medal, from the Management Division of The American Society of Mechanical Engineers, for outstanding achievements in management in 1940 at the two-day Defense Conference at the Engineers Club in Philadelphia on April 22. Shown in photograph are, left to right: Lee P. Hynes, chairman, Philadelphia Section; C. E. Davies, secretary, The American Society of Mechanical Engineers; L. P. Alford, chairman administrative-engineering department of New York University, making presentation; William L. Batt; and George W. Elliott, general secretary, Philadelphia Chamber of Commerce.)

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You . . . Your Family
. . . Your Friends

to take part in the very excellent program of Technical Papers and Social Events of the Society for the 62nd Semi-Annual Meeting, to be held there June 16-19, 1941. Headquarters at Hotel Muehlebach.

Registration work will be expedited if you will supply the information requested on the addressed post card (below) and mail it so that your membership identification may be prepared.

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1941
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MEETING

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6-41

I have checked the Social Events I expect to attend:

☐ Luncheon—Tuesday	☐ Ladies Events for Mrs.-Miss ____________	☐ Sheffeld Steel Co.
☐ Dinner—Tuesday	____________________	☐ Oil Refinery
☐ Luncheon—Wednesday	☐ Inspection Trips	☐ Power Plants
☐ Banquet—Wednesday	☐ TWA Maintenance Shops	☐ Strip Coal Mine

Technical Sessions:

☐ Fuels	☐ Heat Transfer	☐ Hydraulics
☐ Power	☐ Management	☐ Education—E.C.P.D.

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JUNE 16-19

KANSAS CITY

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See pages 397–400 of the May issue for detailed programs

See also pages 484–485 of this issue

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with 200 air-conditioned guest rooms

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1941

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Selection and Training

In opening the Tuesday afternoon session of the Conference, H. W. Jones, director of industrial relations, Atlantic Refining Company, Philadelphia, Pa., who acted as chairman, said that in the present emergency industry would be judged by the result of its national-defense effort, whether the test was a fair one or not. Men, he said, were not available in the open market. The vocational schools were doing all they could, but it would not do to count on them to do the entire job. Industry, he asserted, would have to assume the burden. The two papers read at the session were concerned with different phases of selection and training. One described a program originated in and applicable to normal times in an industry not primarily engaged in national-defense production; the other recounted the methods developed by a concern that was so engaged and that faced heavy demands for expanding production in the metalworking and machinery fields.

Foreman Training at John B. Stetson Company

Dale Purves, treasurer and production manager, John B. Stetson Company, Philadelphia, Pa., told of the origin and development of the foreman-training program of that concern. There was no sure-fire formula for such a program, he said, and he did not know in what respect foremen in a given concern needed improvement. The problem how to improve foremen was an elusive one, but it was a practical problem and had to be approached in a practical way.

He then reviewed the reasons back of the origin of the foreman-training program at the John B. Stetson Company, and explained how the company had been brought to the realization that inasmuch as the company's policies were being interpreted to labor by its foremen, these foremen should be thoroughly familiar with those policies.

Mr. Purves reported a number of general observations on the basic problems of foreman training, such as the necessity of sincere belief on the part of the administration in the value of the program; adoption of the policy that in labor relationships the foreman was the key-man; that foreman training was an educational matter so that a recognition of the differences in educational capacity of the foremen was necessary; that management must participate in the training program; and that "quality rather than quantity" of conferences must be emphasized. He directed attention to a pamphlet "Supervisory Training," issued by the Philadelphia Chamber of Commerce (April, 1941), which he commended highly.

As to methods and results of the program, Mr. Purves said that subjects at conferences related to the company, company finances, its labor negotiations and the issues at stake, costs and budgets, and sales policies. He mentioned several manuals already issued by the company, and an engineering tour of the plant and "open house," that had been successful. The foremen, he said, had developed a workers' manual and had expressed their ideas of what management's policies should be. Principally, he concluded, the program was developing some potential managers.

Training Workers at Baldwin's

In telling how the Baldwin Locomotive Works was meeting the shortage of skilled mechanics, John Converse, apprentice supervisor and assistant to the vice-president of the company, reviewed his military experience during the World War when he had been in charge of instruction in an officers' training camp. He had there learned that it was not only necessary to know what one was to teach another, but it was also necessary to know how to teach.

There were three methods of training a worker: To put him on as a production helper under the supervision of a trained mechanic; to select him from a vocational school where the basis of training in some form of skill had been laid; and to provide such training in a shop school. At Baldwin's, he said, the third method had been considered the best.

He then reviewed briefly the basic methods used at Wright Aeronautical (a combination of the first and second); at American Car and Foundry (the first method); and at General Electric (the third). He discussed in some detail the training methods at Baldwin's, where the trainee, after spending 2 to 4 weeks in the school shop, became a helper in the production shop. Baldwin's was considering, he said, adding the vocational-school method to its present program as the reservoir of men with some skill or aptitude was being depleted. At present, he estimated, about 70 per cent of the trainees had some skill or aptitude. In the face of the handicap of the diminishing number of such men available, it would soon be necessary to reduce the shop-school training period to 1 to 2 weeks.

Answers to questions from the floor, addressed to both speakers, brought forth much discussion of the subject of training. One speaker warned against what he termed "mental bottlenecks," preconceived notions, or blind spots as to what might be done. He cited the case of a girl who had told him she could not get a certain job because she could not read a blueprint. He taught her enough in one evening to permit her to take the job, which she performed satisfactorily. Age limitations were likely to be another bottleneck. Both old and young should be given a chance. It was necessary, he said in confirmation of Mr. Converse's statement, to shorten the training period, and this would have to be done, as speed was extremely important.

Gantt Medal Awarded to Batt

L. P. Alford, as chairman of the Gantt Medal Board of Award, presided at the dinner on Tuesday evening when the medal was awarded to Wm. L. Batt "for distinguished and liberal-minded leadership in the art, science, and philosophy of industrial management in both private and public affairs."

Mr. Alford, after expressing regret that Harold B. Bergen, chairman, A.S.M.E. Management Division, executive committee, and partner, McKinsey and Company, New York, N. Y., who was to have presided, had been called away on urgent business, explained that the Gantt Medal was established in 1929 through a fund raised by a group of Mr. Gantt's friends to memorialize the achievement of this great management engineer, industrial leader, and humanitarian. He reviewed briefly the life and services of Mr. Gantt and summed up his principal achievements and his philosophy. He then introduced Wm. A. Hanley, President A.S.M.E., who made the following statement:

William Loren Batt

William Loren Batt, engineer, manager, and leader in industry. Within ten years after graduation from Purdue University, as a mechanical engineer, Mr. Batt was administering the major responsibilities of general manager of his company, engaged in the engineering and manufacture of antifriction ball bearings. Five years later, after a consolidation of business interests in which his company participated, he became president of SKF Industries, Inc. This position he still holds.

His leadership, however, has been much wider than that represented by his own company, as shown by the posts of responsibility he has held and the honors he has received. In public affairs he is chairman of the Business Advisory Council of the United States Department of Commerce. He is also chairman of the Division of Engineering and Industrial Research of the National Research Council. In his national engineering society, The American Society of Mechanical Engineers, he has served as member, chairman of numerous committees, and president in 1936. His alma mater conferred upon him the degree of Doctor of Science. In foreign affairs he has been thrice decorated by King Gustav V for aid in promoting relations between the United States and Sweden. This listing of recognition of achievements might run on.

In the field of management he has shown his seemingly unlimited capacity for leadership. His own company has made a notable success under his direction. Since January, 1940, he has served as chairman of the board of the American Management Association. In 1938 he was chairman of the executive committee of the Seventh International Management Conference held in Washington, an occasion that brought together representatives from all the industrial nations of the world. Since that congress he has been president of the International Committee on Scientific Management.

In these several relations he has contributed much to the philosophy and statesmanship of management. As evidence, at a meeting of the National Association of Manufacturers in 1938, at a time when he was chairman of the Resolutions Committee of the Association, he spoke these words:

> "The consumer must get an adequate product at a fair price. The employee must get steady employment at a fair wage. Finally, only, may come the fair return to stockholders, and this primarily to assure the flow of capital necessary for new enterprises.
>
> "It is not a very palatable doctrine to put the stockholder last among the obligations of enterprise, and I am sure many people in this room will not agree with me.
>
> "Yet today I think we will all agree that top management has problems of a totally different character from the problems that occupied top management fifty years ago. Today, management is concerned in social problems; and the extent to

which government may engage in business today depends upon what we do about them."

In these days of national stress he is giving himself and his abilities to his country in a management position of extreme difficulty. As deputy director of production, in the Office of Production Management, he is carrying a major responsibility in the national-defense program. Included in his task is the coordination of the manufacture of all aircraft, machine tools, ordnance, merchant and naval ships, and the other weapons of war.

I now present, as the recipient-elect for the Henry Lawrence Gantt Memorial Gold Medal for 1940, William Loren Batt. The award is made for distinguished and liberal-minded leadership in the art, science, and philosophy of industrial management in both private and public affairs.

Batt Calls for Statesmanship in Management

On behalf of the Gantt Medal Board of Award, Mr. Alford then presented to Mr. Batt the medal, a certificate bearing the citation of the award, and a copy of the life of Gantt.

Mr. Batt, in responding to Mr. Alford, expressed his feeling of profound humility in receiving an award which he had won through "extra curricula" work made possible because he had surrounded himself with trusted people who would work. It had not been his intention to make a speech, but inasmuch as John D. Biggers, director of production, Office of Production Management, who had been scheduled for an address had been called away, he felt under obligation to do more than express his appreciation.

He quoted Mr. Knudsen as saying that what the country needed more than anything else was statesmanship in management, and he called on all managers to be statesmen. With statesmanship in management, he said, we would have defense and be able to preserve our institutions.

He had been impressed with the discovery that labor leaders did not want to run business but wanted good managers to run business for them. He spoke of the responsibilities and problems of management in the present emergency, saying that we must not make the mistake of underestimating the expense involved, and warned of the possible effects that what may be done in the emergency would have upon postwar problems. Postwar conditions would also call for statesmanship in management, he said.

Labor Problems Under National Defense

The viewpoints of labor, management, and the government on the subject of labor problems under national defense were set forth in three papers read and discussed on Wednesday morning. Labor's point of view was presented by Clinton S. Golden, director, Northeastern Region, Steel Workers Organizing Committee, Pittsburgh, Pa. Fred A. Krafft, labor relations, American Viscose Corporation, Wilmington, Del., gave the case for management. The attitude of the government was presented by Henry Baker, Jr., U. S. Conciliation Service, U. S. Department of Labor, Washington, D. C., who read a paper that had been prepared by Dr. John R. Steelman, director of the service.

Although Mr. Golden and Mr. Krafft protested that they would prefer to speak extemporaneously, each read a prepared paper with the explanation that choice of words, to avoid misquotation, was important in controversial questions of broad national interest.

Mr. Golden preferred to refer to the subject as an "employer problem" rather than "labor" problem, and spent much time in reviewing recent labor controversies in the steel industry. He called for consideration of the proposal of Philip Murray for "industrial councils," and for the use of marginal firms in the steel industry. Given half an opportunity, he said in closing, labor would do its share. Would management cooperate in an "all out" effort? On the answer to this question might depend the fate of democracy.

Mr. Krafft pointed out that collective bargaining had become the law of the land. Strikes were "big news," but statistics showed that strikes had decreased and that there had been a greater number of strikes in the 1913–1920 period than recently. At present, strikes were unpopular with the public. Antagonism toward the Wagner Act was diminishing and reorganization of the National Labor Relations Board had changed the attitude of management toward the Board. The present Board, he said, was earning the confidence of industry, labor, and the public. The fact that there were 3000 collective-bargaining agreements in force was an indication that business had accepted collective bargaining. What industry had to quarrel about was the tendency to state demands before collective bargaining had been initiated, the overexpansion of collective-bargaining trends, the lack of proper union leadership, labor czars, and racketeering. The responsibility, he said, rested equally with employers and labor, both of which must be brought to believe in conference and compromise.

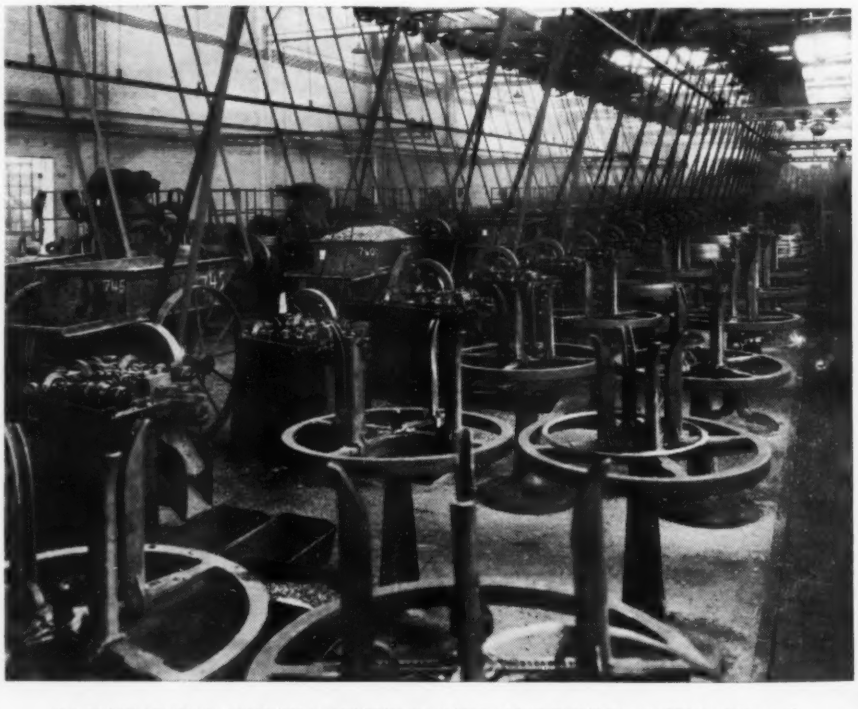
Discussion touched on many interesting questions, such as why a closed shop was so frequently demanded, coordination of the steel industry, assignment cards and the checkoff, and the effect of such technological advances as the strip mill. Mr. Golden, Mr. Krafft, and numerous persons in the audience debated these questions ably and realistically.

R. P. Brown Addresses Luncheon Meeting

The concluding session of the Conference held on Wednesday afternoon followed a luncheon with the A.S.M.E. Philadelphia Section at which Lee P. Hynes, chairman of the Section and president, Hynes Electric Heating Company, Philadelphia, Pa., presided. Richard P. Brown, chairman of the board, Brown Instrument Company and vice-president, Minneapolis-Honeywell Regulator Company, addressed the luncheon meeting on "All-Out Participation by Management for National Defense." Mr. Brown's address was broadcast over station KYW. Following the broadcast, Wm. A. Hanley, President A.S.M.E., thanked Mr. Brown and emphasized the importance of "all-out" effort.

S. Ray Talks on Quality Control

Manufacturing inspection procedure at the Wright Aeronautical Corporation, Paterson, N. J., was described by S. Ray, chief inspector of the Manufacturing Division of that company. Discussion showed that there was much interest in training of inspectors, inspection routine and organization, and responsibility for spoiled work.



BATTERY OF NAIL MACHINES, SHEFFIELD STEEL CORPORATION, KANSAS CITY, MO.

(These automatic nail machines, making every type of nail, tack, and brad, will be seen on inspection trip to plant during A.S.M.E. Semi-Annual Meeting. See story on pages 484–485.)

Fourth A.S.M.E. National-Defense Meeting Stresses Need of All-Out Effort

Dr. Stanley Truman Brooks Speaks on "Union Now With Britain"

THE needs of all-out national defense, how they are being and can best be achieved through stepped-up armament production, and the problems involved in meeting these needs, was the theme of the Fourth A.S.M.E. National-Defense Meeting at the William Penn Hotel, Pittsburgh, Pa., May 2. Due to the stress of defense work, several last-minute revisions in the original program were necessary, but in spite of these forced revisions the meeting was highly successful and counted an attendance of over 300. Representatives of the Army, Navy, and Air Corps treated the defense problem from the viewpoint of the services, while the vital defense industries were represented by men in close contact with the production and supply of aluminum, rubber, and steel.

Frank B. Bell Presides at National-Defense Session

The National-Defense session opened with the presentation of a discussion of ordnance production and requirements by Lt. Col. James L. Guion, executive officer of the Pittsburgh Ordnance District. This paper, "Review of Ordnance Material," was accompanied by slides and motion pictures of the latest mechanized Army ordnance and tests of this equipment. Lt. Col. Guion stated that: "Fifty-five per cent of the cost of the new tanks is represented in the many parts manufactured largely in the Pittsburgh District."

The second paper of this session, "Problems Involved in Inspection of Naval Materials," was presented by Capt. Frederick L. Oliver, inspector of naval material, Pittsburgh District. He stated that: "The Pittsburgh district is responsible for 20 per cent of the total material purchases of the Navy," and went on to say that the Pittsburgh Office had inspected 19.5 per cent of all materials purchased in the United States for the Navy in the last six months.

Major Benj. S. Kelsey, pursuit project officer, U. S. Army Air Corps, Wright Field, flew from Dayton, Ohio, to give his paper, "Blitzkrieg and Total War," in which he treated the defense problem as the Air Corps faces it. Having recently returned from Great Britain, where he served as Assistant Military Attaché for Air at the American Embassy in London, he reported on his observations and the air problem confronting England. He stated that: "The blitzkrieg is not something new and lightning-fast—it is, in reality, very slow. It takes years to prepare for it, and it moves fast only at the instant it strikes." He went on to say that "total war can be met only by total defense," and that to stop it required the destruction at the sources of materials and production.

Frank B. Bell, president of the Edgewater Steel Company and chief of the Pittsburgh Ordnance District, presided at this session.

Aluminum and Steel in National Defense

The session on Materials of Defense was opened by a paper: "Aluminum and National Defense," by Safford K. Colby, vice-president, Aluminum Company of America. Mr. Colby stated: "Since nearly 90 per cent of the weight of a military plane is aluminum, the importance of this light metal for national defense in this type of war becomes immediately apparent. . . . . . So far, no essential deliveries have been held up by lack of aluminum," but civilian uses have had to suffer.

In tracing the advance in aluminum production, Mr. Colby said the combined production of primary aluminum for 1942 should exceed 800 million pounds. Whether this will meet the full requirements of defense depends upon the progress of the war. "What the future holds cannot be predicted."

In an excellent paper by Dr. Webster N. Jones, director of engineering at the Carnegie Institute of Technology, on "Rubber and National Defense," he told of recent advances in the field of synthetic rubber, and declared: "Synthetic rubber is now a reality. Experimentation is at an end. We need a government subsidy of at least $100,000,000 for the actual production of this synthetic to assure complete independence for this most essential raw material." The demand for rubber in this country today is 600,000 tons a year. It would be possible to meet at least one third of this demand immediately with the synthetic product, he declared.

The third paper of the Materials of Defense session, "Steel and National Defense," was presented by T. J. McLoughlin, assistant to vice-president in charge of operation, Carnegie Illinois Steel Company. Mr. McLoughlin stated that while the transition from civilian to defense production in the steel industry has required a "terrific" change, "there can be no question that the steel industry will cooperate fully with the government. We are producing at more than 100 per cent of normal capacity, and are going to keep it up." Up until now the steel industry has met all defense needs.

This session was presided over by Sumner B. Ely, consulting engineer and vice-chairman of the Pittsburgh Section, A.S.M.E.

Heat-Treating

The first paper delivered at the session on Heat-Treating was "Developments in Continuous Annealing of Steel Strip," by J. D. Keller, Associated Engineers, Pittsburgh, Pa. Mr. Keller described a new method in the annealing of strip which reduces the complete cycle of heating and cooling in the case of 0.01-inch stock from 36 to 54 hours to only 1 or 2 minutes. He stated that the adoption of continuous annealing will remove the last noncontinuous link in the chain of steel-strip production. The furnaces used are of the tower type and the strip makes several vertical passes through the heating zone and additional passes through cooling chutes while surrounded by a protective gas atmosphere. Electrically heated furnaces of this type are already in operation annealing tin-plate stock. The paper was chiefly concerned with the design of gas-fired furnaces for a normal strip speed of 200 fpm and with the various handling devices for unwinding the strip from the coil, welding its front end to the rear end of the preceding coil, passing the strip through the furnace and cooler while maintaining the proper tension, cutting out the weld and winding the strip again into a coil, and transferring the coils to and from the unit.

Controlled Atmosphere

"Controlled Atmosphere" was the title of the paper presented by J. R. Gier, Jr., of the Ferrotherm Company and formerly research engineer, Westinghouse Research Laboratories. This paper gave a description of the new balanced protection atmosphere for hardening steels without loss of surface carbon and without damage by oxidation. The new hot-wire gas analyzer that measures the carbon pressure of the gas and permits accurate adjustment of gas compositions to the requirements of various steels, was also described. These developments permit substantial savings in the cost of finishing heat-treated metal parts, and in many cases offer the technical advantages of an improved product. These advantages were brought about by the avoidance of all surface damage during heat-treatment that normally occurs in the conventional method. Mr. Gier's paper was discussed by M. H. Mawhinney, consulting engineer, Pittsburgh Crucible Steel Company.

The Heat-Treating session was presided over by Prof. W. Trinks, professor of mechanical engineering, at the Carnegie Institute of Technology.

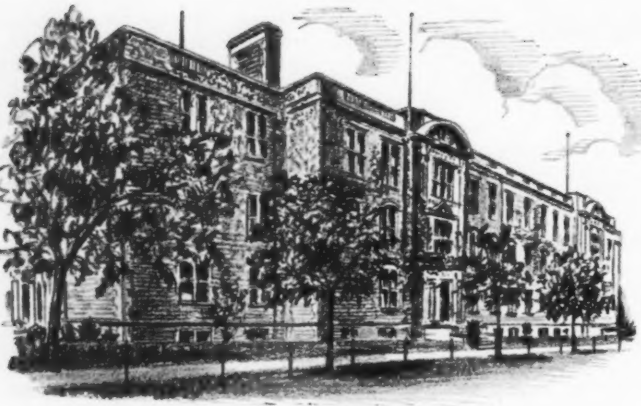
Steam Power Sessions

The Steam Power session included two papers, the first of which, "Mechanical Features of Frank R. Phillips Power Station," was delivered by Walter H. Jones, mechanical engineer, Duquesne Light Company. This was the first paper which has been given on this new addition to the Duquesne Light Company's generating capacity. The Frank R. Phillips Station will have an initial capacity of 60,000 kw, consisting of a single unit, taking 850 psi, 900 F total temperature steam from two 500,000 lb per hour boilers.

The second paper, "Mercury-Vapor Turbines and Boilers," was presented by H. N. Hackett of the General Electric Company, Schenectady, N. Y. This paper presented in detail the latest developments in mercury-vapor equipment and stated that the development work had now reached the point where this equipment was ready for widespread application.

Presiding at this session was Thomas E. Purcell, general superintendent of Power Stations, Duquesne Light Company.

Malcolm R. McConnell, chairman of the Pittsburgh Section, A.S.M.E., presided at the luncheon session, at which Dr. Stanley Truman Brooks, of the Carnegie Museum, Pittsburgh, spoke on "Union Now With Britain."



ENGINEERING BUILDING OF THE UNIVERSITY OF PENNSYLVANIA

University of Pennsylvania Host for Applied Mechanics Meeting, June 20-21

D. Robert Yarnall, Dinner Speaker, to Give His Impressions of England in 1941

THE Engineering Building of the University of Pennsylvania in Philadelphia, Pa., will be headquarters for the eighth national meeting of the Applied Mechanics Division of the A.S.M.E., June 20 and 21.

Cooperating in the technical program with the Applied Mechanics Division are the Heat-Transfer Division of the A.S.M.E. and the Committee on Applied Mechanics of the Structural Division of the American Society of Civil Engineers.

The complete technical program of the meeting was published in the May issue of MECHANICAL ENGINEERING, page 401, with papers and authors listed under four technical sessions; dealing with vibrations, elasticity and plasticity, heat transfer, and fluid mechanics and thermodynamics.

Dr. John A. Goff, Toastmaster

The dinner on Friday evening, June 20, is to be held in the Maine Woods Room of Old Bookbinder's with Dr. John A. Goff, director of the department of mechanical engineering at the University of Pennsylvania, as toastmaster. The speaker of the evening will be D. Robert Yarnall, Fellow A.S.M.E., vice-president of the American Friends' Service Committee, whose subject "My Impressions of England as I Saw It in January, February, and March" is of compelling interest.

Special sight-seeing trips are being planned for the women in attendance at the meeting. Philadelphia abounds with historical sites and a regular tour is being planned to cover them. There will also be a very special trip to the Valley Forge Reservation.

Laboratories Open for Inspection

The engineering and physics laboratories of the University will be open for inspection during the meeting and an official trip is being arranged to certain of them for those who may be interested.

With an interesting and valuable program of papers, with the University of Pennsylvania as host, with the Philadelphia Section of the A.S.M.E. cooperating, the eighth national meeting of the Applied Mechanics Division of the A.S.M.E. will afford ample opportunity for stimulating discussion and the relaxations of good fellowship.

Eighth Annual E.C.P.D. Report Now Published

THE eighth annual report of the Engineers' Council for Professional Development for the year ending October, 1940, is now ready for distribution. Copies may be obtained at a nominal price through the Secretary of E.C.P.D., 29 West 39th Street, New York, N. Y. In addition to information on the Council, its charter, policies, participating bodies, officers, committee members, and list of publications, are included reports of the chairman, John P. H. Perry, to the Council, at the Annual Dinner, at Pittsburgh, Oct. 24, 1940, and of the committees on Engineering Schools (with a list of the 1940–1941 delegatory committees, accredited undergraduate curricula, and directing of schools), Professional Recognition, Student Selection and Guidance, and Ways and Means (with 1939–1940 financial statement). An account of the 1940 Annual Meeting, Pittsburgh, Pa., and résumé of the committee reports and speeches, appeared in MECHANICAL ENGINEERING, December, 1940, page 897.

1941 A.S.M.E.-A.I.M.E. Fuels Meeting, Oct. 30–31, at Easton, Pa.

W. G. CHRISTY, chairman of the Fuels Division of The American Society of Mechanical Engineers, has announced that the 1941 A.S.M.E.-A.I.M.E. joint fuels meeting will be held at Easton, Pa., October 30 and 31. At this meeting, Mr. Christy said, there will be a two-session symposium on the proposed coal-testing code, a preliminary report on which appeared in MECHANICAL ENGINEERING, November, 1940, page 790.

Advanced Mechanics Courses at Brown

BROWN University, Providence, R. I., announces for a 12-week period during the coming summer advanced courses in mechanics together with opportunity for research. The courses are proposed as a method of giving "additional training to men who have used, or wish to use, mathematics in handling advanced problems in applied mechanics, initiating competent students into research in this field, and directing attention of mathematicians and others to the urgent need for research workers and to possible means of meeting this need permanently."

At the summer session, June 23–Sept. 13, 1941, three courses in various phases of (1) partial differential equations, (2) fluid mechanics, and (3) elasticity and an advanced seminar in fluid mechanics and elasticity are planned. There will be regular series of lectures of visiting professors of the first rank.

For further information apply to Dean of the Graduate School, Brown University, Providence, R. I.

A.S.M.E. Professional Divisions Outline Objectives

Will Give You a Check List for Your Registration

THE attention of the members of the A.S.M.E. is called to the series of articles appearing in the advertising pages of the current issues of MECHANICAL ENGINEERING on the objectives of the various professional divisions of the Society.

In April, on page 40 of the advertising section, the objectives of the A.S.M.E. Aviation Division activities for 1941 were stated together with the names and addresses of the personnel of its executive and general committees.

In May, on page 30 of the advertising section, the objectives of the A.S.M.E. Management Division were published, together with the names and addresses of its executive committee.

And so it will go, through the coming months until all seventeen A.S.M.E. Professional Divisions have stated their cause for being.

Check these statements over to be sure you are registered in the right division for your particular interests.

A.S.M.E. Power Test Codes Discuss Speed Regulation and Heat Value of Fuels

Meeting of Main Committee, April 7, 1941

AT a meeting of the main committee of the Power Test Codes held in New York on April 7, a report was received from committee No. 20 on speed-, pressure-, and temperature-responsive devices, and the chairman reported conversations with the Power Generation Committee of the A.I.E.E. concerning a recommended specification for governing devices of prime movers driving electric generators, a subject which has evoked much interest of late.

Speed Regulation

There is some confusion of nomenclature and in regard to the desirable characteristics of the functions of this class of apparatus. In some papers presented at the 1939 A.S.M.E. Annual Meeting two authors pointed out the need of a document that would reconcile this confusion and provide a basis for a standardized specification covering speed regulation that might be employed in purchase specifications for prime movers to drive electric generators. It is obvious that the power test code on speed-responsive governors, published in 1927, if revised and brought up to date, would be a useful factor to that end.

The foregoing circumstances resulted in a reorganization of committee No. 20, upon which were appointed representatives of the three interested A.S.M.E. professional divisions, Power, Hydraulic, and Process Industries, under the chairmanship of C. Richard Soderberg, and the scope of the code was increased to include speed-, pressure-, and temperature-responsive devices.

The Power Generation Committee of the A.I.E.E. has also been active on this subject. There was discussion at the Swampscott meeting in June, 1940, and again at the annual meeting in Philadelphia in January, 1941. On the latter occasion seven technical papers were submitted on the subject of regulation, five of which were directly related to steam-turbine governors.

The chairman of the A.S.M.E. Power Test Codes Committee reported that he had discussed the proposal that a joint A.I.E.E.-A.S.M.E. committee be appointed for the purpose of drafting the recommended specification with Walker Cisler, chairman of the A.I.E.E. Power Generation Committee, and that as a result the Board of Directors of the A.I.E.E. had passed a resolution supporting the appointment of the proposed joint committee. The chairman of the Power Generation Committee has already nominated five A.I.E.E. representatives.

The test code necessarily sets up appropriate nomenclature and provides test rules for determining the performance of the various regulating functions, and in so doing describes the functions. It could not, however, under the sponsorship of the Power Test Codes, prepare a recommended specification that would set up the desirable or recommended numerical values for these functions as required for the various applications of prime movers.

The underlying studies required for the preparation of both documents, the test code and the specification, are identical. It is proposed, therefore, that the A.S.M.E. representatives on this joint committee be made up of members of the test-code committee active in the preparation of the test code, and that they be under the sponsorship of the A.S.M.E. Power Division.

Inasmuch as members of manufacturing organizations predominate on the test-code committee, it was agreed that the following members of the mechanical-engineering departments of public-utility organizations be invited to accept appointment on the test-code committee: J. E. Baker, Pennsylvania Water and Power Company; S. W. Fiala, American Gas and Electric Company; W. C. Holmes, Consolidated Edison Company of New York, Inc.; A. E. Parker, Columbia Engineering Corporation, Cincinnati, Ohio; H. E. Stickle, Boston Edison Company.

Internal-Combustion Engines—High Vs. Low Heat Value

The question of the appropriate heat value, high or low, to be employed in the calculation of the thermal performance of gas engines received much discussion. The committee engaged in the revision of this code had agreed that the performance of liquid-fuel engines should be based on the high value and that of gas engines on the low value. Objections to this agreement were recorded by some members of the main committee who held that the performance of all engines should be based on the high heat value. The matter appeared to be of importance and there seemed to be cogent reasons for both views. The matter was therefore referred to the members of the main committee and to the members of committees on Definitions and Values and on Gaseous Fuels.

The members of committee No. 17 who are members of organizations building gas engines point out the following: (1) Because of the varying hydrogen content in gases, performance based on the high heat value would be meaningless. The hydrogen combines with oxygen during combustion forming water vapor which is not available for use in the engine. The output and heat rate of a gas engine is solely dependent on the low heat value. (2) The low heat value of gaseous fuels can be determined easily and accurately by calculation from continuous-flow calorimeter observations. (3) Performance guarantees of gas engines could not well be made based on the high heat value because the composition of the gas is not usually known when making guarantees. This value may vary from zero to 18 per cent. (4) The low heat value applies equally to engines using liquid fuels, but the low value in this case is not as easily determined with accuracy. Inasmuch as the hydrogen content in all liquid fuels is nearly constant, the more easily determined high heat value is regarded as the more satisfactory basis. Hence comes the proposal to employ the two bases.

In favor of the use of the high heat value for all purposes it was pointed out: (1) It is long-established practice in the United States to employ the high heat value for all fuels. (2) Contracts for purchases of fuels, including gaseous fuels, and adjustment clauses in contracts are based on the high heat value. (3) This question has arisen in the main committee a number of times in years past always with the decision that the high value should be employed for all fuels. (4) To employ one basis for gas engines and another for liquid-fuel engines in computing heat rates or thermal efficiencies is inconsistent, particularly as some engines use both fuels. Furthermore, under the proposed bases, a gas engine would show a lower heat rate or higher thermal efficiency than a liquid-fuel engine if both engines were of equal quality in ability to convert potential heat into work.

It was conceded that to state the test performance of a gas engine based on the high heat value, however meaningless, in addition to that based on the low heat value presented no particular hardship on the manufacturer.

It was first proposed that it shall be mandatory that the test results of all types of engines be based on the high heat value and in the case of gas engines that provision be made to permit the additional inclusion of their performance based on the low heat value. It was pointed out that this would in nowise preclude guarantees being based on the low heat value without consideration of the high value.

Following further discussion it was agreed that the test performance of gas engines shall be reported as based on both the high and low heat value. This decision affects the codes on Definitions and Values and on Gaseous Fuels, the revisions of which are nearing completion.

Centrifugal Compressors and Blowers

There has been discussion in the past concerning the relative value and desirability of determining air quantities by means of pitot tubes or by means of nozzles or orifice plates. The opinion of the individual committee has been divided on this point. It was agreed that the code covering centrifugal compressors, exhausters, and fans shall include the nozzle and orifice-plate method, and that the code covering fans shall include the pitot-tube method.

A.S.M.E. Committee on Consulting Practice

IN connection with the report of the Committee on Consulting Practice, an abstract of which appeared in MECHANICAL ENGINEERING for March, 1941, pages 244 and 245, the Executive Committee of the Council of The American Society of Mechanical Engineers took the following action at its meeting in Atlanta, Ga., April 1, 1941:

Voted: To authorize publication of the following statement in MECHANICAL ENGINEERING and on any future publication of the report: "This report of the Committee on Consulting Practice was approved by the Council solely for the information and guidance of the members of the Society."

National Meeting and Exhibit of A.S.M.E. Oil—Gas Power Division

Kansas City, June 11-14

A FEATURE of every national meeting of the Oil and Gas Power Division of the A.S.M.E. is the exhibit of engines and accessories built by leading manufacturers. This year as in other years those attending the Conference to be held June 11 to 14, 1941, in Kansas City, Mo., with headquarters at the Hotel President, will find the exhibit room a congenial place to see the latest in equipment and to "talk shop" with manufacturers.

Both the time and place for this Conference are well chosen, for those in attendance can stay right along for the Semi-Annual Meeting of the A.S.M.E. to be held in the same city June 16-19.

The technical program for the Oil and Gas Power Meeting which follows presents an interesting and valuable array of papers dealing with current and pressing problems in this field. The Conference will undoubtedly repay attendance.

WEDNESDAY, JUNE 11

10:00 a.m.
Registration

Register at desk in twelfth-floor lobby. Registration fee for members and exhibitors is $1.00, for nonmembers $2.00. This fee covers a file of preprinted papers and a copy of the proceedings, to be published later with complete discussion. There is no registration fee for women

2:00 p.m.

New Developments

Chairman, H. E. Degler

The Chrome Plating of Cylinder Bores, by H. van der Horst

Application of Compression-Ignition Oil Engines to Aviation, by V. L. Maleev

Instrumentation Used in Development and Testing of Diesel Engines, by C. R. Maxwell and K. M. Brown, Caterpillar Tractor Co., Peoria, Ill.

THURSDAY, JUNE 12

9:30 a.m.

Power Plants

Chairman, G. C. Boyer

Design of Diesel-Engine Foundations, by Kenneth Larkin

Centrifuging of Fuel and Lubricating Oil, by C. W. Bryden

Continuous Maintenance of Lubricating Oil, by W. C. Bauer

2:00 p.m.

Inspection and Maintenance

Chairman, Lee Schneitter

Inspection Instruments and Procedures for Diesel Engines, by E. R. Spencer.

Diesel-Engine Casualty Experience, by H. V. VanderEb

Instruments and Automatic-Control Apparatus for Diesel Engines, by W. H. Sisson

8:00 p.m.

Diesel Quiz

Master of Ceremonies, C. G. A. Rosen

Match your wits with the experts—see how much they, and you, know about oil and gas power. Submit questions in advance to G. C. Boyer, Burns & McDonnell Engineering Co., Kansas City, Mo. If the "experts" can't answer your question, you win a free ticket to the banquet

FRIDAY, JUNE 13

9:30 a.m.

Research

Chairman, W. L. H. Doyle

Hydraulic Characteristics of Fuel-Injection Nozzles, by O. F. Zahn, Jr.

Release Pressure Measurements for Indicating Diesel-Engine Performance, by B. H. Jennings and T. E. Jackson

Theoretical Consideration of Power Loss by Combustion Knock, by C. W. Good

2:00 p.m.

Inspection Trips

Inspection trips planned will cover various phases of the oil and gas power industry, including engine building, pipe-line pumping practice and the maintenance shops of a large air line. Check in at the registration desk for full details and for transportation

2:00 p.m.

Golf Tournament

The sports-minded will have a chance to try their golfing skill and that of their fellow members on one of Kansas City's good courses. Prizes for the winners and an afternoon's relaxation. Register at the desk.

7:00 p.m.

Banquet

Toastmaster, C. E. Beck

Speaker, Tom Collins, Sunday Editor, *Kansas City Journal*—"Luck, Its Care and Feeding"

SATURDAY, JUNE 14

9:30 a.m.

Supercharging

Chairman, L. T. Brown

Results From Operating Supercharged Engines in Pipe-Line Pumping Service, by J. B. Harschman and W. G. Heltzel.

Test Results With Underpiston Supercharging, by E. S. Dennison.

Program Planned for Women

A full round of social activities is being planned for the women in attendance at the meeting. Complete information will be available at the registration desk.

Banquet Reservations

Reservations for the banquet should be forwarded directly to Mr. Glenn C. Boyer, Burns & McDonnell Engineering Co., 107 West Linwood Boulevard, Kansas City, Mo. Tickets are two dollars a person.

THE ROUND-UP COMMITTEE HAS FUN

(*Facing the camera left to right:* Harold Carlson, general chairman for the Round-Up; Miss Marianne La Mott, R.N., American Airlines Stewardess, who helped with the arrangements; Geo. J. Nicastro, chairman of the entertainment committee for the Round-Up. *Back to camera:* Walter W. Lawrence, chairman of arrangements for the Round-Up and Mrs. Lawrence. See story on page 495.)

AT THE SPRING ROUND-UP

(*Left to right:* E. E. Clock, Clock Engine Co., Passaic, N. J.; G. P. Hemstreet, Hastings Pavement Co., Hastings-on-Hudson, N. Y.; Prof. W. I. Slichter, Columbia University; Frank Jacobson, Seamlex Co., Inc., Long Island City, N. Y.)

Over 800 Attend Metropolitan Section Spring Round-Up at La Guardia Field

Climaxes Successful Year With Inspection Tour of Equipment, Flights Over City, Informal Dinner, Lively Entertainment, and Group Singing

THE Metropolitan Section of the A.S.M.E. flew high in many ways in the course of its Third Annual Spring Round-Up, held at La Guardia Field, Queens, New York, on the afternoon and evening of Thursday, April 24, under the direction of Harold C. R. Carlson.

Over eight hundred members of the A.S.M.E and their guests took part in one or more of the featured parts of the Round-Up program which began at three o'clock in the afternoon and for some attending did not end until the wee hours of the following morning. Of this number about six hundred took in the detailed inspection trip of American Airlines headquarters, hangars, repair and maintenance shops, radio room, and pilot-training headquarters, up to seven o'clock.

Exactly 602 members and guests took twenty-minute flights in the 21-seat American Airlines Flagships following a notable informal dinner attended by 703. It was for many the first flight taken in their lives, and a notable experience for even the experienced passengers to fly for twenty minutes over bejeweled Manhattan after sunset. The course of each flight included the Triborough and George Washington Bridges, a complete circle of Manhattan via the Hudson and East Rivers, the skyscraper areas, upper New York Harbor, and the Statue of Liberty. This feature of the program was acclaimed by all taking part, and many a projected business and vacation trip by commercial air line was discussed thereafter in the Kitty Hawk Bar.

The informal dinner in the Kitty Hawk Restaurant overlooking La Guardia Field was a lively affair marked by musical and vocal entertainment supplemented by the antics of a professional magician, plus the spontaneous group singing of popular and college songs old and new.

The affair marked a distinct departure from the programs of the first two Spring Round-Ups, each of which had featured technical sessions followed by stag dinners at the Hotel Astor.

This year's program was designed to provide opportunity for each member to bring his wife or sweetheart, and the success of the innovation will be attested by anyone who attended.

The Round-Up is now scheduled annually as the final meeting of the year for the Metropolitan Section, a climax for each successful year of smaller group meetings. The proposal has been advanced that the 1942 Round-Up depart still further from the technical discussion side, with members attending the Circus at Madison Square Garden in a body.

A. E. BLIRER.

C. B. PECK, CHAIRMAN OF A.S.M.E. PUBLICATIONS COMMITTEE, ENJOYS THE ROUND-UP

Minnesota Section Acts as Host for Student Branch of University of Minnesota on April 30

Three Prizes Awarded by Section for Papers by Students

OVER sixty were present at the annual joint dinner meeting of the Minnesota Section and the University of Minnesota Student Branch held on April 30 at the Coffman Memorial Union.

Dr. Lorenz Straub, chairman of the Section, presided and introduced Gordon Ersted, chairman of the Student Branch, and James A. Colvin who announced the winners of the Section's awards to students for technical papers as follows:

First Prize of twenty-five dollars and an engineering handbook to Phillip H. Teeter for his paper "An Analysis of Costs in Producing Electrical Power for Steam and Hydroelectric Plants." Mr. Teeter gave a brief outline of his prize-winning paper.

Second Prize of fifteen dollars and an engineering handbook to Karl F. Behrens for his paper "The Control of Quality."

Third Prize of ten dollars and an engineering handbook to J. Ralph Bowers for his paper "Modern Features of Automotive Hydraulic Braking."

The main speaker of the evening, Prof. Huber O. Croft, head of the department of mechanical engineering at the University of Iowa, Regional Adviser Engineering Defense Training Programs, and a manager of the A.S.M.E., gave a talk on "Defense Training Programs." He outlined the organization and activities of the work and also touched on the Selective Service Act and how it affects the student and the young engineer. An open forum discussion followed.

Anthracite-Lehigh Valley April Meeting in Reading

ENGINEERING precepts in industrial management was the subject of the paper presented before the Anthracite-Lehigh Valley Section on April 25 at its Reading meeting by R. Devere Hope. He discussed the engineering fundamentals employed in revitalizing sick companies and industries. Following the talk, Prof. W. J. Spivey led the discussion.

Ralph S. Damon Is Guest Speaker at Baltimore

A prediction that air passenger travel would increase 1000 per cent in the next decade was made on March 31 before the Baltimore Section by Ralph S. Damon, who has just been elected president of the Republic Aviation Corporation. He stated that most of the increase would come from persons who would abandon Pullman service to ride the air lanes.

Buffalo Engineers Hear Talk on Tacoma Bridge

Dr. David B. Steinman, consulting engineer, was the speaker on April 16 at the joint meeting of the Buffalo Section of the A.S.M.E. and the Erie County Chapter of N.Y.S.S.P.E. Aerodynamic instability caused the failure of the Tacoma Bridge, he claimed; and using scale models and an electric fan, he showed the setting up, because of wind, of harmonic undulations of increasing magnitude in the span. A light feather touch at selected points on the model prevented the oscillations, indicating where light rope stays might have been applied in the actual structure to cure the trouble.

Electricity in Steelmaking Described to Central Indiana

A paper on "Electricity and the Steel Industry" was given before the Central Indiana Section on April 25 by N. C. Pearcy. He outlined the applications of electricity in steelmaking and the conditions influencing a decision to buy power from a utility or to generate it at the plant. His talk was illustrated with slides and a motion picture, "Making and Shaping of Steel."

75 Attend Cleveland Session on Plastics

A comprehensive discussion of the developments in plastics during the last several years was made by L. C. Currie on April 17 before 75 members and guests of Cleveland Section. The talk was illustrated with demonstrations, charts, and plastic samples.

Students Are Guests of Colorado Section

Students from the Colorado School of Mines were guests of the Colorado Section at its March 28 meeting in Denver, Col. J. L. Ronayne gave a talk on "Practical Significance of Octane Ratings," in which he pointed out the definition and uses of octane numbers. H. L. Potts presented an illustrated talk in which he described the water resources of Denver.

East Tennessee Visits Local Copper Plant

On March 29, 85 members and their guests of the East Tennessee Section were guests of the Tennessee Copper Co. for luncheon and for an inspection trip through the company's plant at Copperhill, Tenn.

Aviation Session Held by Los Angeles Section

On April 1, the aviation group of the Los Angeles Section held its second meeting, which was devoted to production problems in aircraft production. The dinner was attended by 84, and the meeting by 119. Prof. J. W. Roe spoke on "Principles of Jig and Fixture Practice." Courtney J. Hertel followed with a paper on "Interchangeability in Modern Aircraft Production." Of particular interest to those attending the meeting was an exhibition of a number of various standardized holding devices designed especially for aircraft production, jigs, and fixtures.

Selection of Boilers Discussed at Louisville

A review of progress since 1900 in boiler design was given by John G. Martin, member A.S.M.E. and mechanical engineer with Babcock & Wilcox, on March 20 before 48 members and guests of the Louisville Section. Some of the developments which Mr. Martin mentioned were waterwalls, elimination of slagging, and air preheaters. The talk was illustrated with slides.

Milwaukee Section Has Paper on Die Casting

D. V. Stevens, engineer with Kearney & Trecker, presented a talk on die casting, illustrated with slides and samples of castings and dies, before 30 members of Milwaukee Section at the April 9 meeting.

New Orleans Holds Inspection Trip

On March 29, 40 members and guests of New Orleans visited the Gaylord Container Corporation's Bogalusa mill. The Gaylord management, in addition to extending the courtesy of inspecting their plant, was also host to the group at dinner following the inspection tour. Members who arrived early were given the privilege of playing on the company's golf course.

Raleigh and Piedmont Sections Hear Talk by I. J. Karassik

STRESSING the refining of the operation of boiler feed pumps and conservation of the heat energy generated within the pump itself, I. J. Karassik, Harrison, N. J., centrifugal-pump engineer, addressed a joint dinner meeting on the evening of April 21, of the Piedmont and Raleigh Sections of The American Society of Mechanical Engineers.

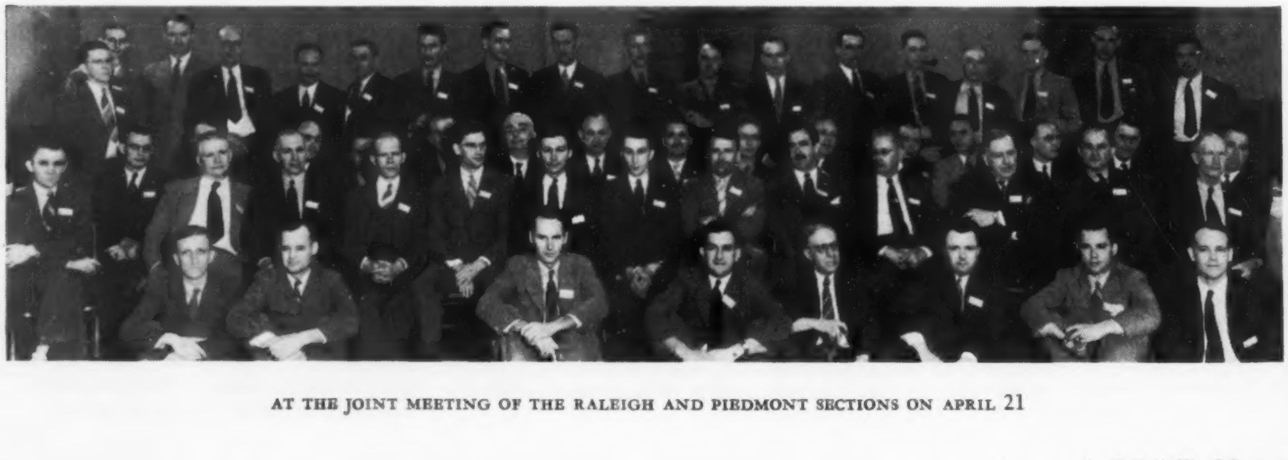
About 65 engineers from all parts of the State attended the session which was the first joint meeting of A.S.M.E. sections ever held in North Carolina.

The meeting was the regular spring gathering of the Raleigh Section and the Piedmont Section was invited to participate. Charles E. Kerchner, Greensboro, chairman of the Raleigh Section, and R. M. Reece, Piedmont Section chairman, presided.

Mr. Karassik's talk came after the dinner. Lantern slides were used to illustrate the talk. An open forum discussion followed.

Petroleum Is Subject of San Francisco Section

About 65 members and guests of San Francisco Section were present at the April 24 meet-



AT THE JOINT MEETING OF THE RALEIGH AND PIEDMONT SECTIONS ON APRIL 21

ing which was arranged by the petroleum group. In place of the scheduled speaker, A. G. Loomis discussed "A Decade of Progress in Petroleum Production, Research, and Technology," and reviewed "Various Phases of the Oil Industry From Prospecting to Plastics." Fred F. Doyle outlined "Problems in Connection With Procurement and Transmission of Natural Gas." One of the interesting points brought out by the latter speaker was the fact that a drop of one degree in temperature in San Francisco resulted in an increase of more than six million cubic feet of gas used.

The improvements in Diesel-electric locomotives from 1924 to the present were discussed by Morris Taylor, assistant engineer, Southern Pacific Railroad, at the May 1 luncheon meeting of the Section.

Television Meeting of Susquehanna Attracts 96

The April 7 meeting of Susquehanna Section was devoted to television. An audience of 96 members and guests listened to Norman Bean who gave a very simple and comprehensive explanation of the principles of television. Slides, parts from a receiver, and a complete receiver were used to illustrate the lecture.

Virginia Engineers and Architects Meet Jointly

Under the sponsorship of the Engineers Club of Hampton Roads, the Virginia Section of the A.S.M.E. and other engineering and architectural organizations met at a joint meeting held in Norfolk, Va., May 2–3. More than 200 engineers and architects took part in the technical sessions, luncheon, and dinner on May 1, and in the inspection trip by boat around Hampton Roads on May 2. Speakers included Dean W. B. Kouwenhouven, Johns Hopkins University, Brig. Gen. James A. Anderson, E. M. Hastings, R.F.&P.R.R., and Prof. J. Ormondroyd, University of Michigan.

From Felt to Hats Is Topic of Waterbury Talk

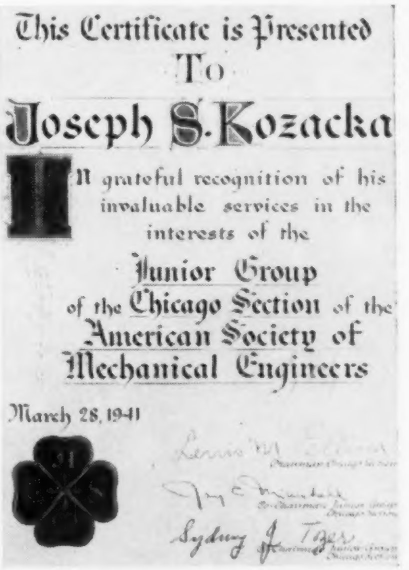
J. M. Green and William Wheeler gave a joint talk on April 9 before the Waterbury Section on the "Manufacture of Hats and the Machinery Involved." Mr. Green outlined the production processes in modern hat making, the machinery used, procurement and preparation of raw materials, formation of the cones, and their shrinkage into the proper shape on blocks. Mr. Wheeler covered the engineering features of the different machines used in the industry.

Dr. Sillcox's Paper Given Before Worcester Section

Originally, Dr. L. K. Sillcox was scheduled to give a paper, "Weighted Wheels," before the Worcester Section on April 10 but a last-minute call to Chicago on National-Defense problems prevented his appearance. His paper was therefore read by Glenn Thompson, eastern representative of the New York Air Brake Co. Some of the topics covered by Dr. Sillcox were railroad signaling, wheel and rail defects, wheel loading, bearing pressures, regenerative braking, air-brake performance, wheel-rail adhesion, automatic rail sanding, and the requirements of high-speed operation.

young engineers out in the field. At the time he was chairman of the Chicago Section, Professor Kozacka revitalized the then dormant Junior Group and helped to make it one of the best in the A.S.M.E. He has also served as chairman of the Student Branch Cooperation Committee and was most active in work for the A.S. M.E. student branch of Lewis Institute.

J. S. KOZACKA



This Certificate is Presented
To
Joseph S. Kozacka
In grateful recognition of his invaluable services in the interests of the
Junior Group
of the Chicago Section of the
American Society of
Mechanical Engineers
March 28, 1941

The illuminated scroll presented to this friend of Juniors was signed by L. M. Ellison, chairman of the Chicago Section, and Jay C. Marshall and Sydney J. Tozer, cochairmen of the Chicago Junior Group. A reproduction of the scroll is shown on this page.

Junior Group Activities

Copy must be at headquarters on the sixth of each month to be included in coming issue

Consulting Engineer Guest Speaker of Milwaukee Juniors

S. J. GATES, consulting engineer of Milwaukee, was the guest speaker at the March 27 meeting of the Milwaukee Junior Group. He discussed many problems encountered in his type of work, such as water rate making, procedure with clients, and the design of special machinery.

Successful Spring Meetings of Philadelphia Junior Group

The spring meetings of the Philadelphia Junior Group started in February with a paper by C. Hoffner on the present position of the machine-tool industry. Discussion amplified such points as the need for machines to produce machine tools and the extreme precision required in the manufacture of modern equipment.

The March meeting was devoted to an illustrated talk on "Neoprene," which covered its structure, properties, and applications. In April, W. A. Tucker gave a paper on high-temperature materials. He discussed physical properties and methods of improving them, the necessary special test methods and equipment for determining these properties, and the need for judgment in selecting the proper test data to obtain suitable materials for a particular application.

Chicago Junior Group Honors Prof. Joseph S. Kozacka

At the annual dinner of the Chicago Junior Group on March 28, a scroll was presented to Prof. Joseph S. Kozacka, associate professor of mechanical engineering at the Illinois Institute of Technology, in recognition of his aid to junior engineers not only through the A.S.M.E. Junior Group but also directly to

E. W. Burbank Dies

EDWARD W. BURBANK, fellow A.S.M.E., who served on the Council of the Society as a manager from 1936 to 1939, died on April 20, 1941, after a prolonged illness which followed a stroke he had suffered in 1939. Mr. Burbank was former manager of the Allis-Chalmers Manufacturing Company's Dallas, Texas, district office, 1922 to 1940.

Sanford of Engineers Club of Philadelphia Dies

WILLIAM H. SANFORD, secretary-treasurer of the Engineers Club of Philadelphia since 1934, died on April 29, 1941, after an illness of several months. Mr. Sanford was well known to A.S.M.E. members in Philadelphia and to engineers from other parts of the country who attended engineering meetings at the Club.

Honored at Michigan

Cooley, Herron, and Neff Cited for Achievement

AT the Engineering Student Open House, University of Michigan, Ann Arbor, Mich, on March 29, three members of The American Society of Mechanical Engineers were among the distinguished alumni cited for achievement: Mortimer E. Cooley, past-president and honorary member A.S.M.E., James H. Herron, past-president A.S.M.E., and Elmer H. Neff, life member A.S.M.E. The citations were as follows:

MORTIMER E. COOLEY: Graduate of the United States Naval Academy in the Class of 1878 and since 1881 identified with this University, as professor of Mechanical Engineering, Dean of the Colleges of Engineering and Architecture, and Dean Emeritus; pioneer in the field of appraisal engineering; a wise and discerning leader in professional education, who throughout a long and fruitful career has deserved the rich honors bestowed by his colleagues and the affectionate respect in which he is held by thousands of Michigan students.

JAMES H. HERRON: Metallurgist, inventor, editor, writer; prominent in the engineering profession in his home city, Cleveland, and in the nation; a graduate of the College of Engineering in the class of 1909 who has gained acknowledged success in the practice of his profession.

ELMER H. NEFF: Bachelor of Science in Mechanical Engineering in the class of 1890; Mechanical Engineer, 1901; one of whose ingenuity and executive ability, applied to the problems of the design, distribution, and proper installation of machine tools, has made him an acknowledged leader in an industry which is fundamental to many others.

Wood-Finishing Report

THE Committee on Wood Finishing of the A.S.M.E. Wood Industries Division has completed a report which will be of interest to members engaged in this industry. The report is available without charge to members registered in the Wood Industries Division of the Society upon request. It is available to members of the Society at 35 cents a copy. The Committee preparing this report is as follows: M. J. MACDONALD, *Chairman*, MAX J. DANZIGER, JOHN E. HANLE, JOSEPH KING, A. C. FEGEL, and THOMAS TROWBRIDGE.

"POWER"
(Photograph taken by C. T. Boyles and shown at the Fifth Annual Photographic Exhibit held during the A.S.M.E. Annual Meeting, Dec. 2–6, 1940, New York, N. Y.)

A.S.M.E. Calendar

of Coming Meetings

June 11–14, 1941
Oil and Gas Power Division
Kansas City, Mo.

June 16–19, 1941
Semi-Annual Meeting
Kansas City, Mo.

June 20–21, 1941
Applied Mechanics Division
University of Pennsylvania
Philadelphia, Pa.

October 12–15, 1941
Fall Meeting
Louisville, Ky.

October 30–31, 1941
Joint Meeting of A.S.M.E. Fuels and A.I.M.E. Coal Divisions
Lafayette College
Easton, Pa.

(*For coming meetings of other organizations see page 22 of the advertising section of this issue*)

Air Corps Needs More Procurement Inspectors

NO small part of the work of securing faster, more powerful, and safer airplanes and equipment is the inspection of aircraft materials. Parachutes, goggles, camera lenses, instruments, and all other equipment must be inspected by competent well-trained men.

Through an examination announced some time ago, the Civil Service Commission has been seeking experienced men for procurement inspector positions in the Air Corps of the War Department. The Commission has not been able to obtain enough men for these positions.

In general, mechanical experience, which may include apprenticeship, is required in the field applied for. For only four options (aircraft, parachutes, propellers, and aircraft materials) need this experience be specifically on aircraft materials. College courses in engineering may be substituted for part of the experience. Applicants will not have to take a written test, but will be rated on their experience and education. For details applicants should consult Announcement No. 6-249, Revised of April 22, 1941.

Original appointments will be made at salaries ranging from \$1620 to \$2600 a year. Opportunities for advancement are excellent. Ap-

(*A.S.M.E. News continued on page 500*)

New Type *Drive*

DELIVERS AMAZING ECONOMIES

New Morse principle—the use of larger sprockets to get higher chain speeds from the same motor r.p.m. It's as simple as that.

Morse high speed Superdrives, built on this principle, deliver amazing operating and space economies; extend the profitable use of silent chain drives into fields where chain drives used to be no more than a wish in engineers' minds.

Now Morse Superdrives, operating smoothly over larger sprockets at chain speeds of a mile a minute or more, set new economies and new standards of efficient operation. Centrifugal force, for years the barrier to high speed chain applications, is really Morse Superdrive's well-behaved helper, actually working to distribute the load over more teeth and reducing chain and sprocket wear to a point so small that it is almost impossible to measure.

Power Transmitting Capacity Zooms Up!

With Superdrive operation, power transmitting capacity rises sharply—increasing faster than chain speeds increase. Chain widths are greatly reduced, with resulting space economies. Cost of the drives is low, often considerably less than other types of drive.

Call In The Morse Man

Take advantage of the economy, efficiency, and long life of Morse high speed Superdrives. Morse engineers will help you put these better drives to work for you. Call in the Morse man near you, or write direct to Morse, Ithaca.

SILENT CHAINS ROLLER CHAINS FLEXIBLE COUPLINGS

MORSE *positive* DRIVES

MORSE CHAIN COMPANY ITHACA N. Y. DIVISION BORG-WARNER CORP.

plications may be filed until further notice with the Secretary of the Board of U. S. Civil Service Examiners at Wright Field, Dayton, Ohio. Qualified persons are urged to apply for details to the Secretary at Wright Field; to any first- or second-class post office; to the U. S. Civil Service Commission, Washington, D. C.; or to any of the Commission's District Offices.

The U.S. Government Needs Aeronautical, Mechanical Engineers

THE production, development, and testing of aircraft and airplane engines is becoming of increasing importance in the National Defense program. Four government agencies are now seeking qualified engineers who can do the critical investigative and research work connected with the development of faster, safer, and more powerful airplanes. Aeronautical training is especially in demand, although the services of qualified civil, mechanical, and electrical engineers are also required.

The U. S. Civil Service Commission has announced open continuous examinations in all fields of engineering. Application forms (Form 8) may be obtained at any first- or second-class post office. The application, when properly filed, is rated immediately, and applicants rated eligible may be certified at once to an appointing officer, may be tendered an offer of employment by wire, and may be at work within a week of filing applications.

Mechanical Engineers Needed for Navy

THE cooperation of The American Society of Mechanical Engineers has been asked to interest young mechanical engineers in the Bureau of Aeronautics of the U. S. Navy. According to a communication from the Bureau of Aeronautics of the Navy Department the requirements are as follows:

The Bureau of Aeronautics is interested in enrolling as aviation specialist officers in the Naval Reserve men who hold mechanical-engineering degrees from accredited universities, who have high personal qualifications, and who qualify physically. Mechanical engineers who either through supplementary studies or practical experience have acquired a knowledge of the following specialties would be given preference: Airplane specifications, instruments, hydraulics, metallurgy, radio, airplane structures, engines, aeronautical draftsmen, fuels and lubricants, and plastics.

Those candidates who qualify in any of these specialties would probably be ordered to definite billets on being commissioned. The other desirable candidates who might not be thus qualified would probably be commissioned and sent on an active-duty status to short special courses in aeronautical engineering before assigned to definite billets.

The men desired would be generally between the ages of 25 and 35 and would probably be commissioned as ensigns or lieutenants (junior grade) in the Naval Reserve. The period of active duty would be indefinite but probably for the duration of the emergency.

Men and Positions Available

Send Inquiries to New York Office of Engineering Societies Personnel Service, Inc.

**29 W. 39th St.
New York, N. Y.** | **211 West Wacker Drive
Chicago, Ill.** | **57 Post Street
San Francisco, Calif.** | **Hotel Statler
Detroit, Mich.**

MEN AVAILABLE[1]

MECHANICAL ENGINEER, 25. One year in furnace design and shop work. One year research in industrial plant, including design of special testing equipment. Two years as instructor, engineering courses at accredited college. Now employed, desires industrial position, East. Me-642.

MECHANICAL ENGINEER, physicist, 44, with wide experience, for administration of a department of research and instrument design. Me-643.

MECHANICAL ENGINEER, 30, graduate of European college with high scholastic standing; 10 years' industrial experience, of this 5 years' development work. Now employed in rayon industry, desires responsible position. Me-644.

MECHANICAL ENGINEER, married, B.S.M.E., 11 years' experience in design, research, maintenance, lubrication, and power-plant engineering. Capable of directing engineering, purchasing, and construction in this type of work. Me-646.

MECHANICAL ENGINEERING EXECUTIVE, 48, many years' responsible experience organizing and operating purchasing and administrative functions. Wide knowledge of materials, having designed, purchased, inspected, and tested. Unusually wide knowledge of both government and private purchasing. Me-647.

MECHANICAL ENGINEER, 25 years' experience in design, construction, operation, and management of all classes of power plants and public utilities. Both mechanical and electrical training. Available immediately. Me-648.

GRADUATE MECHANICAL ENGINEER, 12 years' industrial-engineering, labor-supervision, and plant-design experience. Married, children, reliable, and ambitious. Available for developing and directing an industrial plant or engineering organization. Me-649.

MECHANICAL ENGINEER, 27, B.S.M.E. Six years' diversified steelmill experience including maintenance, development, combustion, instrumentation and automatic controls. Me-650. Chicago.

EXECUTIVE, experience and training adaptable for handling subcontract work separate from regular organization. Full knowledge of systems, drawings, patterns, machining, etc. B.S. degree. Have managed machine shop and foundry. Me-651.

PROFESSOR, engineering mechanics, 35, married. Four years' industrial experience with well-known engineering company, and ten years' teaching experience in mechanical-engineering and engineering mechanics. One year of research beyond doctorate. Available now. Location, immaterial. Me-652-413-D-1-San Francisco.

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[1] All men listed hold some form of A.S.M.E. membership.

POSITIONS AVAILABLE

INDUSTRIAL ENGINEER to serve as secretary of chamber of commerce. Salary, about $6000 a year, depending upon experience and availability of applicant. South. Y-7949.

RECENT GRADUATE MECHANICAL ENGINEER, young, with some practical contact with manufacturing field and knowledge of centrifugal machinery, to act as general engineering-office assistant. Will be required to do some drafting and calculations. New York, N. Y. Y-7976.

MECHANICAL ENGINEER, preferably older man, with experience in power-plant field, to write specifications for heaters, pipe-line water-treatment plants, pumps. Some knowledge of hydraulics and chemistry of water desirable. Permanent. Salary, $2600–$3900 year. South. Y-7998.

INSPECTORS, mechanical and electrical, for contractor on construction of large manufacturing plant. Temporary, four months' work. Salary, $3640 year. Pennsylvania. Y-8000.

INDUSTRIAL ENGINEER to head production department in precision-machine metals plant. Will be in control of planning, dispatching, scheduling progress, and follow-ups. Should be capable of organizing work for production step-up. Salary, $4000 year. New England. Y-8014.

DESIGNER, mechanical, for steam-power-plant work. Should be capable of working alone on design. Must be U. S. citizen. Salary, $3200 year. New England. Y-8032.

CHIEF ENGINEER with technical engineering ability and experience to direct engineering organization. Man should contribute engineering ideas and direct the working organization. This opportunity offers wide expression of ability. Apply by letter including small photograph. Salary, $5000–$7000 year. New England. Y-8043-C.

DEVELOPMENT ENGINEER, six to eight years' experience on miscellaneous mechanical work and machine development. An all-around engineer and some electrical knowledge desired such as some idea on how relays function and familiarity with application of photocells and amplifiers in industrial work. Salary from $3600 year, depending on experience. Middle West. Y-8051-R-982-C.

PIPE DESIGNER capable of calculating pipe stresses. Some machine-design experience also desirable. Must be quick and neat draftsman. Salary $2600–$3120 year. New York, N. Y. Y-8072.

PRODUCTION CONTROL, METHODS, AND PLANNING ENGINEER for small foundry and manufacturing company. Salary, $4000–$5000 year. Western New York State. Y-8073.

RESEARCH AND PRODUCTION ENGINEER experienced in grinding-wheel industry. Salary,

(A.S.M.E. News continued on page 502)

$4000–$5000 year. New York metropolitan area. Y-8082.

SUPERVISING FOREMAN over company's machine shop and certain other foremen of specialized departments. Must have at least two years' training in engineering as well as in production. Opportunity for advancement according to ability. Not just defense work. Salary, $3000–$3600 a year. New England. Y-8088.

EXECUTIVE, about 40, who has some engineering background as well as practical machine-shop experience. Must have pleasing appearance and ability to meet and discuss production matters with chief executives throughout the country. Will be required to do considerable traveling and may be called upon to address large groups of executives. Salary from $5000 year. South. Y-8099.

MECHANICAL ENGINEER experienced in production, inspection, estimating in mechanical industries. Must be able to approve designs and drawings on manufactured equipment. Some traveling required. Salary $3800–$4200 a year. New York, N. Y. Y-8101.

CHIEF DESIGNING ENGINEER, mechanical, experienced in design of all kinds of mechanical equipment in building trades, heating, ventilating, power. $6500 year. South. Y-8115.

PUMP ENGINEER, mechanical, preferably 28–35, experienced in small rotary 20–200 gallon-per-minute industrial pumps, for design, patent research, contact with manufacturing units of company. $3000 year. New England. Y-8119.

ASSISTANT PROFESSOR, graduate mechanical engineer, to teach courses in mechanism, dynamics of machines, and machine design. Must have outstanding training in dynamics and also some industrial experience. Salary, $2500–$3000 a year. Middle West. Y-8137-C.

MECHANICAL ENGINEERS, about 40, with knowledge of materials, machinery and machine-tool products, to expedite, follow-up, and get deliveries of these products. Automobile or aircraft manufacturing experience desirable. Salary open. Detroit, Cleveland, New York, and Philadelphia. Y-8154-D.

MATERIALS-HANDLING ENGINEER, single, preferably graduate mechanical, to make study of plant and design industrial handling methods which will increase product movement from raw material to finished product. Must know all types of conveyers and industrial trucks. Salary $3000–$4000 a year. Considerable traveling. Headquarters New York, N. Y. Y-8166.

ASSISTANT ENGINEER for planning department of manufacturing company. Must be acquainted with machine-shop operations. Salary $3120 a year. New Jersey. Y-8169.

TIME-STUDY ENGINEERS, graduate industrial or mechanical, with one to three years' experience. Salary, $2600–$3120 year. New York, N. Y. Y-8174.

CHIEF ENGINEER for bicycle manufacturer in British India. One- to two-year contract. Previous experience in this special line necessary. Salary open. Interviews in New York, N. Y. Y-8176

DRAFTSMAN who can detail sheet metal, welded and riveted tanks, and piping. Should be able to design and check plate fabrication, pressure tanks, storage tanks, etc. Salary open. Middle West. Y-8187-C.

Candidates for Membership and Transfer in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after June 25, 1941, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member who has either comments or objections should write to the Secretary of The American Society of Mechanical Engineers immediately.

KEY TO ABBREVIATIONS

Re = Re-election; Rt = Reinstatement; Rt & T = Reinstatement and transfer to Member

NEW APPLICATIONS

For Member, Associate, or Junior

AHLSTROM, FREDK. C., Chicago, Ill.
AMENS, CLARK, Reno, Nevada
BENNETT, JAMES, Front Royal, Va.
BODINSON, FRED W., San Francisco, Calif.
BOOTH, THEODORE H., Greensburg, Pa.
BOYAJIAN, JAMES A., Chicago, Ill.
CLARK, DAVID L., JR., Hermosa Beach, Calif.
COLOMB, CLIFFORD, New Orleans, La. (Rt & T)
DEUHS, GERHARD B., Minatare, Neb.
EISKAMP, EDW., Richmond Hill, N. Y.
HARKER, JOHN S., Vineland, N. J.
HEWLETT, ALLEN M., Hawaii, T. H.
JACKLING, DANIEL C., San Francisco, Calif.
KARLA, GUSTAV, Detroit, Mich.
KONGELBECK, S., Bethlehem, Pa.
LUFKIN, EBEN P., Boston, Mass.
MONAGHAN, JOHN J., Denver, Colo.
MOORE, EDWARD F., New York, N. Y.
NABOW, DAVID, Charlotte, N. C.
NELSON, ALFRED M., College Station, Texas
NORGREN, CARL A., Denver, Colo.
PACH, LEO, Greensburg, Pa.
PERCY, W. E., Balboa, C. Z.
ROBINSON, CECIL E., Orange, Va.
ROGERS, A. W., Gorgas, Ala. (Rt & T)
ROHRER, J. H., Philadelphia, Pa.
SEELEY, WIRT D., New York, N. Y. (Rt)
SONNTAG, ALFRED, Moline, Ill.
STETLER, C. O., Jackson, Mich.
STRICKER, ADAM K., JR., New York, N. Y.
SWERDLOW, NATHAN, Philadelphia, Pa.
TIGGES, ALEXANDER J., Boston, Mass.
WEINSTEIN, ISAAC, Ellenville, N. Y.
WELGE, HAROLD B., St. Louis, Mo.
WHITE, IRA M., San Francisco, Calif.
WHITE, W. H., Verona, N. J.
WILHELM, JACK E., West View, Pittsburgh, Pa.
WILLIAMSON, ARTHUR, Burbank, Calif.
WILLIS, ALVIN H., East Pittsburgh, Pa.
WILSON, WILLIAM H., Chattanooga, Tenn.
YOCUM, WILBUR F., State College, Pa.

CHANGE OF GRADING

Transfer to Fellow

DUDLEY, SAMUEL W., New Haven, Conn.

Transfers to Member

BARTON, A. R., Chicago, Ill.
HILL, WM. P., Sparrows Point, Md.
HUGE, E. C., Barberton, Ohio
MILLER, ROLLA L., Arcadia, Calif.
PAMPHILON, G. M., Berkeley, Calif.
SESSIONS, ROBERT C., Cleveland, Ohio
THUESEN, H. G., Stillwater, Okla.
WIST, EDWARD B., Alameda, Calif.

A.S.M.E. Transactions for May, 1941

THE May, 1941, issue of the Transactions of the A.S.M.E. contains:

Mill Drying of Coal, by M. E. Fitze
Steam Generation in Steel Mills, by H. J. Kerr
Coal Resources of Washington, by Joseph Daniels
Burning Characteristics of Washington Coals on Domestic Overfeed and Underfeed Stokers, by H. F. Yancey, K. A. Johnson, and J. B. Cordiner, Jr.
The Radiation of Furnace Gases, by H. C. Hottel and R. B. Egbert
Kaplan Turbine Installations of the Tennessee Valley Authority, by G. R. Rich and J. F. Roberts
A Study of the Development of Skill During Performance of a Factory Operation, by R. M. Barnes and J. S. Perkins
A New Steam Engine and Boiler, by S. L. G. Knox and J. I. Yellott
A Study of Circulation in High-Pressure Boilers and Water-Cooled Furnaces, by John Van Brunt
Recent Developments of the Pease-Anthony Gas Scrubber, by R. V. Kleinschmidt and A. W. Anthony, Jr.
Relationship of Viscosity to Rate of Shear, by L. J. Bradford and F. J. Villforth, Jr.
Effect of Temperature on Coiled Steel Springs Under Various Loadings, by F. P. Zimmerli

Necrology

THE deaths of the following members have recently been reported to the Society:

ARTHUR, RUSSELL W., January 10, 1941
BURBANK, EDWARD W., April 20, 1941
EHRHART, RAYMOND N., April 30, 1941
HOVEY, OTIS E., April 15, 1941
JACKSON, PERCY, February 24, 1941
MARTIN, RINALDO E., March 24, 1941
McMILLAN, CHARLES E., April 16, 1941
MILLER, SAMUEL J., April 20, 1941
NOLTE, CHARLES B., April 29, 1941
OAKLAND, BERNY, April 2, 1941
RECKFORD, JOHN KING, February 20, 1941
RICHARDS, CHARLES RUSS, April 17, 1941
RICHHART, WILLIAM S., April 9, 1941
WRIGHT, JAMES W., June, 1940